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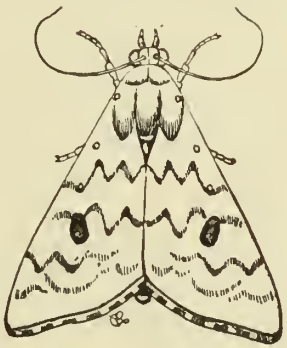
DEPARTMENT OF THE INTERIOR.
UNITED STATES ENTOMOLOGICAL COMMISSION.

BULLETIN NO. 3.

RECEIVED
FEB 14 1880

THE COTTON WORM.

SUMMARY OF ITS NATURAL HISTORY, WITH AN ACCOUNT OF ITS ENEMIES, AND THE BEST MEANS OF CONTROLLING IT; BEING A REPORT OF PROGRESS OF THE WORK OF THE COMMISSION.



By CHAS. V. RILEY, M. A., Ph. D.

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J. Riley del et pinx

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THE COTTON WORM

(Aletia argillacea.)

INTRODUCTORY.

The following text of a circular, distributed last summer in the cotton-growing States, will help to an introduction to this bulletin:

[Circular No. 7.]

RELATING TO THE COTTON WORM.

DEPARTMENT OF THE INTERIOR,
OFFICE OF THE U. S. ENTOMOLOGICAL COMMISSION,
——— ———, 18—.

Mr. ———:

DEAR SIR: The undersigned has for many years keenly felt that there was great need of more accurate knowledge of the habits of the Cotton Worm (*Aletia argillacea*) and of the other insects injuriously affecting the cotton plant, as also of more satisfactory means of counteracting their injuries. Recognizing the vast importance of the subject to the people of the South, one of his first efforts, after accepting the position of entomologist to the Department of Agriculture, in May, 1878, was to commence a special investigation looking to those ends.

An appropriation to the Department was obtained for the purpose, and the investigation was carried on under his direction up to the time of his resignation, on the first of May last. Since that time Congress has required the United States Entomological Commission to continue the work, and said Commission, at a late meeting, decided to place this part of its work in his charge. On behalf of the Commission he would, therefore, call the attention of correspondents to the following questions and topics, with the request that answers thereto, or experience thereon, be returned to him some time before October next.

Some correspondents whom this circular will reach may already have answered a more detailed one, sent out last year by the writer while connected with the Department of Agriculture. He would beg such to again give their experience on the fewer topics of the present circular.

He will be glad to receive figures, either photographs or drawings, of machines or contrivances employed for the wholesale use of the Paris-green mixture, either in the fluid state or as a powder; or any other kinds of machines or traps employed for the destruction of the insect. Models of such are still more desirable, and may be sent by express, unpaid, to the headquarters of the Commission. Correspondence is solicited whenever any expense must attend the carrying out of these requests, in order that authority may be given to make the necessary outlay and thus insure the refunding of the amount.

Respectfully,

CHAS. V. RILEY,
Chief U. S. E. C.

1. During what year was cotton first grown in your State, county, or locality?

2. How many years elapsed after cotton first began to be grown before the worm began to work upon it?

3. Is the worm most dreaded after a mild or after a severe winter?

4. Do wet or dry summers favor its multiplication?

5. What is the earliest date at which you have known the worm to appear in spring?

6. In what locations does it most often first appear?

7. What is your experience, and what are your views, as to the winter habits of the insect?

8. What natural enemies of the worm among birds, quadrupeds, or insects are you familiar with?

9. What has been the result of the efforts to allure and destroy the moths, and what methods have proved most satisfactory? Give your estimate of the relative value for this purpose of poisoned sugar, molasses, and vinegar, or other poisonous substances, and fires.

10. Are the moths most attracted to sweetened substances when smeared upon trees, boards, &c., or when contained in vessels in or near which lamps may be lighted?

11. Are any flowers known to be attractive to the moth? If so, specify them and their season of blooming.

12. What do you know, from your own observation, of the influence of jute grown near or with the cotton?

13. Has anything been found more generally useful and applicable, or cheaper, than the use of the Paris-green mixture, or of arsenic in some form, to destroy the worms?

14. Have you known of any injurious effects following the use of this poison, either to the plant, to man, or to animals?

15. State what you consider the best and most effective method of destroying the worms in your section.

16. State the cost per acre of protecting a crop by the best means employed.

☞*Correspondents will confer a favor by numbering the replies to correspond with the questions, and by writing on but one side of the paper.*

The need of such an investigation, and even of a much more thorough one than the limited means so far appropriated therefor by Congress have permitted, is, I venture to believe, made apparent from the following pages. Mr. Townend Glover, during his earlier connection, as entomologist, with the Patent Office and the Department of Agriculture, gave much time to the study of the insects affecting cotton, and published in the Agricultural Reports for 1854 and 1855 much valuable information there anent, which has been a text for most subsequent writings on the subject. The science of entomology was then in its infancy in this country, and Mr. Glover labored under many difficulties in the proper determination of species and in other ways, which necessarily prevented that scientific accuracy and thoroughness which is desirable. Yet to his labors and those of a few Southern men like the late Thomas Affleck, of Brenham, Tex., and Dr. D. L. Phares, of Woodville, Miss., we owe all that was known and in any way reliable on the subject up to within the present decade; while his copper-plate figures of the principal insects affecting the plant, of which figures he published in 1878 a limited number of copies for distribution at his own expense, are so admirable and instructive that it is cause for regret that they were not long since issued, with appropriate text, by the Department of which he was so long the entomologist.

It may safely be said that up to 1878 scarcely any facts had been added, by direct observation, to those which Professor Glover had published regarding the Cotton Worm twenty-five years ago.

During my direction of the investigation under the Department of Agriculture many interesting chronological, statistical, and biological facts were obtained on the subject of the Cotton Worm. As one of my last efforts while yet connected with said Department was to get the printing of 10,000 copies of a special report on the subject ordered by Congress, it will devolve on my successor, Prof. J. H. Comstock, to prepare the material thus collected for publication. Professor Comstock was one of the special agents whom I had engaged to assist me, and did most satisfactory work; he is, therefore, well qualified for the labor that has fallen upon him. Most of the more practical questions, however, as well as those which necessarily required more extended research than could be encompassed in a single year, were left for future solution, and it is to these that, on the part of the United States Entomological Commission, I have been primarily devoting my attention the past summer.

This bulletin is a brief summary of results thus far obtained and is issued as a prodrome of the final, more exhaustive report which the Commission hopes to be able to make. It will serve, also, as an indication both of what has been accomplished and of what is yet to be accomplished; for few persons have any idea of the amount of time and labor required to obtain positive, final and satisfactory results in the many paths that lead from an investigation of this kind.

The text has for the most part been prepared in the intervals of active field-work, and most of the classified details and experiences upon which the statements and conclusions rest, are reserved for the final report. By this course the preparation and printing of the bulletin have been expedited, and it has been kept within due bounds as to size. For the same reasons none of the other many insects affecting cotton are treated of, though a great deal of information respecting them has been collected for our final report.

In order to treat exhaustively of several of the more important questions, it becomes necessary to study the history of cotton culture in all other countries as well as in the United States, and also to more definitely classify the cotton regions of the latter. In its first report on the Rocky Mountain locust the Commission found it convenient and even necessary to divide the country over which that insect occurred, into three regions, representing, respectively: 1st, The permanent breeding-grounds where the species is always found. 2d, The subpermanent region to which it frequently spreads, but from which it may be absent; and, 3d, The temporary region which it visits at irregular intervals, and in which, as a rule, it dwells but a single year at a time. These divisions have a *raison d'être* in the facts observed, but we recognize that, like all classificatory divisions, they are more or less arbitrary.

Some similar classification of the cotton belt will also greatly aid in the treatment of this Cotton Worm question, and as a temporary classification, to be elaborated in future, I have divided said belt into, 1st, the southern or permanent portion, where the first worms annually

appear and the moths in all probability hibernate; 2d, the northern or temporary portion, in which the insect does not hibernate, but into which it spreads, either by gradual dispersion or by more sudden migration, from the permanent portion. The dividing line between these two portions must needs be difficult to define, because there is an uncertain region that may, according to season or circumstance, belong to either, and also because of the limited observations that have yet been made. Taking the early appearance of the worms as a basis, the southern portion may be thus roughly defined: Beginning with Texas, it includes the region south of the Galveston, Harrisburg and San Antonio Railroad, excluding perhaps the extreme western portion, but extending somewhat farther north along the river bottoms. In Louisiana and Mississippi it includes the valley of the Mississippi River and its tributaries, with uncertain northern limits. In Alabama it is represented by the limestone cotton belt south of Montgomery, though probably extending farther north to the east of that point. In Georgia it does not extend north of Albany on the west, but doubtless includes the sea islands along the coast, as also those of South Carolina, though at the present time cotton cultivation is limited to Saint Catharine's Island. In Florida it includes all parts where cotton is grown.

The facts given in this bulletin are, many of them, for the first time published. If they oppose previously accepted views and opinions, they at the same time dispel many errors that have heretofore prevailed as to some of the more important questions in the natural history of the species. The pamphlet is prepared for the benefit of the planter and popular reader, with as little of the technicality of science as is consistent with clearness and precision, and with such matter as more particularly interests the scientific reader printed in smaller type.

The principal aim of the Commission has been to discover some safer and cheaper remedy than any previously in use. Its efforts in this direction have been limited by the means at command; yet, as the context will show, they have resulted in materially cheapening the cost of protecting the crop, and there is promise of still greater improvement.

The Commission has had the aid and co-operation, in this southern part of its work, of a number of correspondents; but its acknowledgments are especially due to Mr. E. A. Schwarz, of Detroit, Mich., who has acted as special agent in South Texas, where he remained from the beginning of May till the middle of September; also to Prof. E. A. Smith, of the University of Alabama, at Tusealoosa; Prof. J. E. Willet, of Mercer College, at Macon, Ga.; Dr. E. H. Anderson, of Kirkwood, Miss.; Judge J. F. Bailey, of Marion, Ala.; Mr. W. H. Patton, of Waterbury, Conn.; Mr. W. A. Henry, of Ithaca, N. Y.; and General A. C. Jones, of Washington, D. C. My acknowledgments are also due to Professor Comstock, Prof. A. R. Grote, of Buffalo, and Judge J. W. Jones, of Virginia Point, Tex., for co-operation while I was yet connected with the Department of Agriculture. My own field labors during the

year have covered all the cotton-growing States, except Florida and South Carolina.

The figures when enlarged generally have the natural size indicated in hair-line, and the Messrs. Hoen & Co., of Baltimore, deserve credit for the faithful manner in which they have reproduced the colored plate by their admirable lithocaustic process.

Appreciating the value of cumulative experience from all parts of the cotton belt, and on all points where experience may differ, I would respectfully solicit correspondence from all who may find interest in these pages, and who have facts to communicate.

C. V. R.

WASHINGTON, D. C., *November* 3, 1879.

RECEIVED
FEB 12 1890
DEPT. OF AGRICULTURE

THE COTTON WORM.

(ALETIA ARGILLACEA Hübn.)

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1. DESTRUCTIVENESS OF THE WORM.

LOSSES OCCASIONED BY IT.

An impartial calculation of the money loss to the cultivator caused by injury to the great staples of the country from their insect enemies, is sure to startle us by its magnitude when the loss is aggregated. Such a calculation of the losses which the Cotton Worm (not to speak of other insects) inflicts on the people of the South, based upon the somewhat imperfect statistical data at command, leads to the following interesting conclusions, which for the most part receive explanation in the facts embodied in this bulletin. The calculation embraces the fifteen years since the close of the civil war, and was made by Mr. C. R. Dodge, and verified for me by Mr. J. R. Dodge, the statistician. Any extraneous causes which tend to retard the growth of the plant, also tend to swell the percentage of injury by the worm when it abounds. Where an early stand is secured, with thorough cultivation and exemption from other causes of injury, there the percentage of loss is least, even in bad Cotton Worm years. The percentage of loss is, also, dependent on location. When the injury is done early in the season, the loss in localities of heaviest production, or where the fields are numerous and contiguous, is nearly double what it is where the fields are more isolated. In years of severe injury, from 30 to 98 per cent. of the crop may be ruined upon some plantations, while on others the loss will be trifling. The highest average of loss is sustained in the southern portion of the belt, as in Florida and southern Texas. It increases also in a westerly direction, commencing with Georgia at 16 per cent., or 16 bales out of every 100 of an average crop for fifteen years, and ending with Texas at 28 per cent. In the northern portion of the belt the averages are low, ranging from 5 to 8 per cent. for the same period; while in many parts of it, and notably in North Carolina, the worm appears so late as to generally do more good than harm by removing the luxuriant top foliage, and thus admitting the sun to the lower bolls and hastening their maturity.

The following table shows the amount of loss in bales and dollars for each State in a year of severe visitation.

State.	Per cent. of loss.			Crop.	Losses.	Money loss.
	Highest.	Lowest.	Average for State.	Average number of bales for 15 years.	Average number of bales for worst years.	For worst years at $50 per bale.
Florida	.....	.....	24	49,700	12,000	$600,000
Georgia	25.1	15	16.5	474,600	78,422	3,912,000
Alabama	25.2	12.5	17.8	536,700	95,790	4,789,000
Mississippi	24	15	17	706,000	123,070	6,150,000
Louisiana	.....	.....	20	438,000	89,740	4,437,000
Texas	35	20	28	525,000	148,125	7,406,000
South Carolina	.....	.....	05	224,500	11,225	560,000
Tennessee	.....	.....	05	147,000	8,365	418,000
Arkansas	.....	.....	08	347,000	27,760	1,380,000
North Carolina	.....	.....	.....	.....	.....	.....
Totals	.....	.....	15.5	3,449,200	594,497	29,711,000

This table shows a possible loss of about $30,000,000 in years of general prevalence of the worm, or an average of 15½ per cent. total annual loss, viz., $12,934,500, for all the cotton States since the war. That it was equally great before the war there is no reason to doubt, for while severe visitations have, perhaps, been more frequent since that time the injury has been greatly diminished by the use of Paris green and other arsenical poisons since the year 1873.

2. POPULAR AND SCIENTIFIC NAMES FOR THE INSECT.

Among planters the worm is very often termed the "Caterpillar," or the "Cotton Caterpillar," and not infrequently the "Army Worm." I have elsewhere shown* why this last term should be discountenanced in the literature of the subject, unless prefixed by the word "Cotton," and both for the sake of brevity and to prevent confusion the name used in this bulletin, and by which the insect in this larva state is very generally known, is, on the whole, preferable. In Louisiana, more particularly, the French term "Chenille," meaning caterpillar, is commonly employed. For the perfect insect the term "fly" is more often used in some parts of the South than the term "moth," but the latter is preferable from an entomological view.

As to the scientific name, the species was first described by Thomas Say, in 1827, as *Noctua xylina*, in a letter to Dr. C. W. Capers, published in the *Southern Agriculturist* (vol. I, p. 203), but overlooked by most later writers. Harris, in his Correspondence, placed the "Cotton Moth" near the genus *Ophiusa*, while later authors more correctly referred it to Hübner's genus *Anomis*. Mr. A. R. Grote first gave a correct synonymy of the species in 1874,† and pointed out that Hübner

*Second Mo. Ent. Rep., p. 37.

†Proc. Am. Ass. Adv. Sc., 1874, B., p. 18.

had figured and referred to it in 1822 by the appropriate name of *Aletia argillacea* here employed. The differences between *Anomis* and *Aletia* are slight, but by accepting them as of generic value, our Cotton Moth becomes the only species of its genus in the United States, and there is no reason why the word "Aletia" should not come into general and popular use to designate the species in all its stages, just as so many other scientific terms for familiar plants and animals have been, by example, added to the common language. Some such short simple term is so desirable in popular reference to the insect that it is frequently used in this bulletin in the hope of its being adopted.

3. CHARACTERS AND STAGES OF THE INSECT.

The Cotton Worm, like most other insects, and all belonging to its Order and Family, exists in four distinct states, which differ much from each other. They are, 1st, the *egg;* 2d, the *larva* or worm; 3d, the *chrysalis;* 4th, the *imago* or moth.

The worm MUST hatch from an egg deposited by the female moth. All theories to the contrary, such as its supposed spontaneous development from the plant, or its origin from the cotton-seed, are therefore utterly without foundation. They need emphatic denial here, because of their prevalence not only among the negroes and the more ignorant, but among intelligent men unfamiliar with the principles of biology. Such theories always have been, and doubtless always will be, entertained in explanation of the apparently sudden appearance and rapid multiplication of any insect or other organism in which the preliminary phases of the phenomena are easily overlooked or with difficulty traced. Reserving minute descriptive details for future report, I will briefly indicate the characteristics of these four states, so as to enable the reader unacquainted with any or all of them to recognize the species in any phase of its growth and to distinguish it from all other insects. On the plate, more particularly, I have represented, of natural size, all the different phases, as they may be observed in the field.

THE EGG.

The egg is 0.6 mm wide, circular, much flattened and ribbed, as at Fig. 1. Of a bright bluish-green or sea-green when first laid, it contrasts sufficiently with the warmer green of the leaf to be easily detected, even by the naked eye when practiced (Plate I, Figs. 1, 1). It is laid singly, and fastened with such firmness as not to be easily removed without injury. It is laid by preference during early summer on the under side of the larger and lower leaves, and seldom more than three or four are found on one leaf. In con-

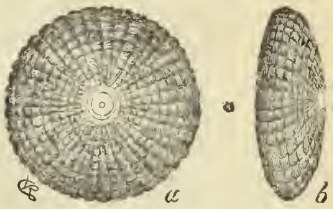


FIG. 1.—EGG OF ALETIA: *a*, from above; *b*, from side. (After Riley.)

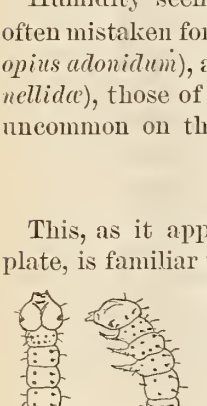
finement and exceptionally in nature it will be laid on the upper surface of the leaf, or on any other exposed part of the plant. In autumn, more particularly, the upper leaves receive a due share of the eggs, and I have counted as many as 49 eggs and egg-shells on a single leaf. With development the color becomes more dingy, or pale yellowish, frequently with brownish borders or a green curve, due to the coiled embryo, which may be seen through the transparent shell. The young worm or larva eats its way out through an irregular hole on one side, usually during the morning, ere the dew is dissipated, and from three to four days after oviposition. This is the average time elapsing between the laying of the egg and the hatching of the worm therefrom in ordinary midsummer weather, but the time varies with the temperature, and a much longer period is required in spring and late autumn.

All eggs perish that are unhatched when overtaken by frost, as is not infrequently the case. The vacated and glistening shell is more readily noticed upon the green background than the unhatched egg. At Fig. 1 I have shown one of the more perfect eggs both from above (*a*) and from the side (*b*), and greatly enlarged, so as to indicate the sculpture, the natural size being indicated between them.

Humidity seems to favor hatching. Aphides or plant-lice are quite often mistaken for the eggs of this insect, while the "Mealy bug" (*Dactylopius adonidum*), a species of *Aleurodes*, the eggs of the lady-birds (*Coccinellidæ*), those of the Lace-wings (*Chrysopa*), and even a minute snail, not uncommon on the cotton plant, are likewise so mistaken.

THE WORM OR LARVA.

This, as it appears in its different stages of growth on the colored plate, is familiar to every planter. Varying greatly in ground-color, it is characterized by the particular position of the black piliferous spots upon the head and upon the body; by the white ring which surrounds each of the latter; by its pure white subdorsal lines and by its elongate and slender form. It is a semi-looper, the first pair of prolegs being very much reduced in size and seldom used, and the second pair, though longer, only about half as long as the succeeding pair.*



a. *b.*

FIG. 2.—NEWLY-HATCHED COTTON WORM: *a* back; *b* side view. (After Riley.)

The worm molts five times during growth and changes appearance but little after the first molt. Exceptionally only four molts are suffered.

The newly-hatched worm measures 1.6 mm, is of a uniform pale dingy yellow, marked as in Fig. 2, with polished black, slightly elevated spots, each bearing a short pale hair. Before the first skin is shed the color often be-

*In alcoholic specimens the first pair often appear as mere tubercles without clasping hooks, but these really exist, though withdrawn from sight. The legs are perfect, therefore, and simply atrophied. In this respect the larva of *Aletia argillacea* differs from that of another species (apparently *Anomis exacta* Hübn.), which occurs in South Texas, for in this last species the claspers are wanting and the legs really obsolete and replaced by mere tubercles. Otherwise the resemblance between the two larvæ is such as to cause them to be easily confounded.

comes slightly greenish and sometimes inclines to orange. After the first molt the piliferous spots are more conspicuous, the hairs from them longer and black and the characteristic markings appear, though less distinctly than after the second; but from this time on the prevailing color is very variable, being either entirely of various shades of pale or pea green, or more or less intensely black along the back.

The normal number of larval molts is five. This is the number which I have observed during the autumn months, while in midsummer, when the development is more rapid, I have on several occasions traced but four. The term of larval existence varies from one to three weeks.

There is a very general belief among planters that the first worms of the season are pale and the late ones dark, and while both light and dark worms may always be found together in spring, summer, or fall, it is true that the green ones predominate early in the season and the dark ones later.*

Immediately after molting, the body is pale and without marking—a rule with all molting animals. After the earlier molts, the cast-off skin, which remains more or less fully stretched, is sometimes eaten.

Some of the peculiarities in the habits of the worm deserve mention here because of their practical bearing.

Until after the second molt it always remains on the under side of the leaf, feeding upon the parenchyma, and leaving untouched the coarser veins, stomata, and upper skin or epidermis. The leaves where they are thus feeding present a blotched appearance, the semi-transparent epidermis becoming pale yellowish, and these blotches are, as a rule, at once distinguishable from other somewhat similar ones made by a few other insects.†

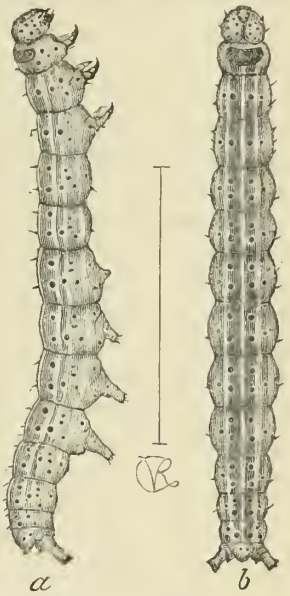


FIG. 3.—FULL-GROWN COTTON WORM: *a* from side; *b* from back; twice natural size. (After Riley.)

After the worm begins to eat entirely through the leaf, which is usu-

* The larva of *Plusia dyaus* Grote is not uncommon in spring and early summer on cotton. Being a semi-looper and bearing in color and mode of pupation a general resemblance to the *Aletia* larva, it is often mistaken therefor by planters. It is invariably pale green, without dark shades, and may have helped to the popular belief in the first worms being green. But while I have invariably found dark individuals among the earliest and throughout the summer generations, I was struck during a trip made last October through Mississippi, Alabama, and Georgia by their great preponderance, the intensity of the black (often obliterating the white annuli and subdorsal stripes), and the early stage of growth (often after the first molt and very generally after the second) in which it appeared. In the spring and early summer the black is more often confined to the fifth and sixth stages.

† The young larva of *Spilosoma acrea* makes somewhat similar but larger blotches.

ally before the third molt, but sometimes later, it instinctively ascends toward the top of the plant and feeds on the more tender foliage, "ragging" it, to use the expressive language of the planter.

It can let itself down by a web from the moment of birth, but can also fling itself from one part of the plant to another in a manner quite characteristic. The fling or jump is made by bending the fore and raised part of the body to one side and then suddenly jerking it to the opposite side, relaxing meanwhile the three hind pairs of legs by which it held to the plant. This is a quite common mode of motion when disturbed, and the normal way of getting from one plant to another. The maximum distance which a worm can thus jump in a horizontal direction is about two feet, and it almost invariably alights on its legs. During chilly weather in autumn this motion is feeble and can be easily watched. When not feeding, the worm either rests stretched straight on some part of the plant or may be seen swaying its fore body from side to side, holding the while by the hind prolegs.

Though preferring the foliage, it will, when hard pushed, eat every exposed part of the plant, even barking and girdling the stems. In feeding on the bolls, however, it does not bore like the Boll Worm (*Heliothis armigera*), but eats the external parts as well as their contents. It cannot thrive on any other plant than cotton, and is evidently confined in its diet to the different species of the particular genus *Gossypium*. At all events there is yet no satisfactory evidence to the contrary, all experiments made confirming the belief.*

As one correspondent naively puts it, "the worms feed only on cotton and one another," the cannibalistic propensity being freely indulged when the occasion presents. It is a common remark that the presence of the worm is easier detected by smell than by sight. The planter says that he can "smell the worm." There is a peculiar odor arising from the excrement, but particularly from the gnawed and mutilated leaves that gives rise to this saying; but where the worms are numerous and large enough to render it obvious, there they have already existed several days, perhaps weeks, in smaller numbers.

When numerous enough to utterly defoliate a field before they have attained full growth, the worms will travel in all directions on the ground, and they have been exceptionally known to collect together and travel in vast bodies in their search for fresh food.

THE CHRYSALIS.

Having obtained full growth, the worm, in the language of the planter, "webs up," forming for protection a more or less perfect cocoon, usually

*Mr. Schwarz succeeded in feeding one from the hatching period till it transformed to chrysalis on a species of Morning-glory (*Ipomea commutata* Roem & Sch.), but the chrysalis was imperfect, and finally perished. I find that quite a number of persons believe that the worm feeds on Abutilon and Pokeweed (*Phytolacca*), but the belief rests solely on the fact that these plants are often defoliated when the Cotton Worm is stripping the cotton fields. In the case of *Phytolacca*, as Professor Willet has been able to prove, it is an entirely different worm which does the work, and the same is doubtless true of the Abutilon. Mr. Phillip Winfree, of Mulberry Creek, La. (De Bow's Ind. Res. of S. & S.W., 1852, p. 173), remarks that it feeds in the West Indies on a plant called the salve bush, resembling somewhat the common Mullein.

within the fold or roll of a leaf, sparsely lined with silken meshes. Here it contracts and thickens, the distinctive marks are nearly obliterated, and the green color acquires a verdigris hue. Within twenty-four hours, in midsummer, the skin splits just back of the head, and is gradually worked to the end of the forming chrysalis, now soft and green, but acquiring in the course of an hour or more a brown color and firmer consistence. This chrysalis state lasts, on an average, about a week in hot weather, but may extend to thrice that time with lower temperature. Where necessity obliges, the worm will spin up on any other plant or in any situation that offers shelter. In confinement it will make a cocoon on the surface of the ground, covering and disguising the same with particles of earth, or it will even transform on the ground without silk or shelter. Such cases rarely if ever occur in a state of nature, but when the worms are very numerous in a field the chrysalides frequently have their leafy protection eaten away, so that many of them either hang by the few hooks at the extremity, or fall to the ground. In no case, however, does the worm burrow in the ground as does the Boll Worm, or could the moth issue from the chrysalis were the latter accidentally buried even an inch beneath the surface.

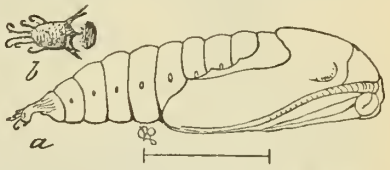


FIG. 4.—CHRYSALIS OF ALETIA: enlarged to show cremaster from the side (*a*) and from beneath (*b*). (After Riley.)

We shall presently see, in discussing the hibernation of the species, that it is quite important to distinguish between this chrysalis and others that closely resemble it, and to enable the reader to more readily do so an enlarged outline is here introduced. The color varies from light mahogany-brown to deep purplish-brown, while the general form is that belonging to many other chrysalides. Neither form nor color can serve then as distinguishing traits, and the same is true of size. The peculiar form of the cremaster, or anal tubercle bearing the hooklets (Fig. 4), will prove the best and safest criterion, and any chrysalis found in a cotton field that has a different tip may be safely determined as not that of the Cotton Worm. The duration of the chrysalis state also averages about fifteen days. I have known it to last but seven days, and Mr. Glover records its lasting thirty days.*

THE MOTH, OR IMAGO.

The moth measures from 1⅛ to 1½ inches from tip to tip of wing when these are expanded. Its general color, above, is olivaceous, more or less effectually subdued by lilaceous or purple hues, and often having a clay-yellow, or faintly golden cast. The under side is more gray, with nacreous reflections.

The markings that more particularly characterize and distinguish it from all other North American moths are certain undulating vinous or

* Report Department Agriculture, 1856, p. 73.

carmine lines across the front wings, a dark oval spot near their disc containing pale scales, which usually form a double pupil (the basal or inner one the smallest and whitest), *and three white specks dividing the space between this dark spot and the shoulder in about three equal parts.* (Fig. 5, *a a a.*)

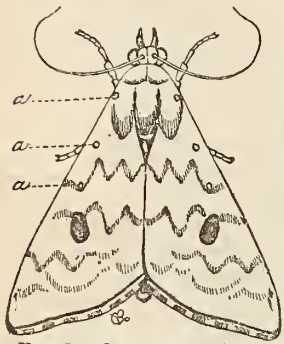


FIG. 5.—OUTLINE OF ALETIA: showing characteristic marks and white specks (*a a a*)—twice natural size. (After Riley.)

The sexes are not readily distinguishable, as the relative stoutness of the male antennæ compared with those of the female is so slight as to be no safe guide. An examination of the tip of the abdomen, especially from the side, will always show the difference, however, the last joint in the male (Fig. 6, *a*) being the longer and more full, and the pale tufts of hair that belong to the withdrawn genitalia* showing within or beyond the squarely docked tip; while in the female (Fig. 6, *b*) this joint is shorter, more pointed, and obliquely truncate beneath.

The habits of this moth can only be studied at night, as, like almost all the rest of its family, it is nocturnal. During the day it simply starts up when disturbed, and darts by swift and low flight to some other sheltered spot a few yards, or perhaps rods, away. After sunset, however, it may be seen leisurely hovering about, either bent on the perpetuation of its kind or feeding upon whatever sweets it can get, whether from the cotton or from other sources. It is very strong and swift of wing, and capable, when the necessity arises, of flying long distances. In alighting upon the plant it generally turns its head downward, and when it rests, the wings are but shallowly roofed, the front ones closed along the back and fully hiding the hind ones. In this respect it may always be distinguished from the parent of the Boll Worm, which rests with the front wings partly open and not entirely covering the hind ones.

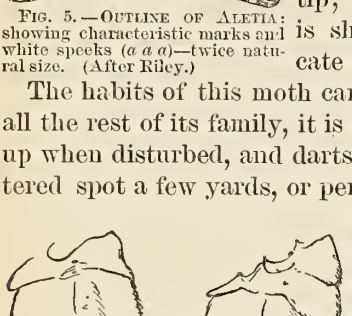


FIG. 6.—COTTON MOTH: *a*, male abdomen; *b*, female do.—enlarged. (After Riley.)

The female begins to lay her eggs in from two to four days after issuing from the chrysalis, the time varying with the different generations and according to temperature.

In experiments which I have made with moths confined in vivaria,

*The male genitalia in this species are remarkable for having two extensile organs, usually retracted and showing as dense tufts of hair, but capable of extension to thrice the length of the rest of the armature; also for two attenuated double-jointed spines which lie when at rest in a sheath on one side of the penis with the points extending beyond it, but which in action bend back at right angles therefrom.

eggs have sometimes been laid thirty-six hours after issuing, and the moths have continued laying for twenty-one nights, the number laid each night ranging from 4 to 45.

Examination of the ovaries of females at different seasons shows a much greater prolificacy than belongs to most moths, as the number of well-developed ova may reach 500, and of potential ova half as many more. In confinement it is difficult to obtain from one female more than 300 eggs, but that fully double this number are produced in the field during the height of the season there can be little doubt, while the average number may be estimated at about 400.

The natural food of the moth, as first shown by me in the fall of 1878,* is the sweet exudation from the glands upon the mid-rib of the leaf and at the base of each lobe of the involucre of the cotton plant. Nevertheless it is attracted to all kinds of sweets, and in most parts of the South it finds a bountiful supply in the exudation from the spikes of *Paspalum læve*, a tolerably common grass, but particularly in that copiously secreted by glands at the apex of the peduncle, just above the pods of the Cow-pea (*Dolichos*). In the spring of the year, as Judge Bailey, of Marion, Ala., has observed, it may often be seen in the evening feeding in numbers, first from the blossoms of the Chickasaw plum, and subsequently from those of the peach, Chinese quince, mock orange (*Cerasus Carolinensis*), the early apples, and blackthorn. Later in the season, when the glands above mentioned begin to exude and the tree blossoms are no more, the moths do not seem to be attracted by other nectar-storing flowers, since observations during the past two years by myself and assistants have resulted in finding but one species of verbena (*Verbena aubletia* L.) frequented, even where both moths and all sorts of flowers were abundant. But fruits of all kinds as they ripen are resorted to, and figs, apples, peaches, plums, apricots, grapes, persimmons, and even melons are often greatly injured.

FIG. 7.—COTTON MOTH: *a*, with wings expanded; *b*, with wings closed. (After Riley.)

Carefully examined, the tongue is seen to be armed along its terminal half with stout and sharp spines projecting forward from the upper surface and increasing in density toward the tip, which is beset with them on all sides. It is by means of this spinous tip of the tongue that the moth works a hole in these fruits, and is thus enabled to absorb the more liquid portions. Apple pomace is especially attractive to them.

*See *Atlanta* (Ga.) *Constitution*, September 20, and *Scientific American*, November 15, 1878.

4. TIME ELAPSING FROM ONE GENERATION TO ANOTHER.

This varies according to temperature, and therefore according to season. There is increasing activity and acceleration in development from the first appearance till July, and thenceforth decreasing activity and retardation in development till frost. Thus in midsummer the whole cycle of individual life, from the hatching to procreation, may occupy less than three weeks; while in spring and late autumn it may occupy twice that time. Taking the whole season through, however, the time from the egg of one generation to that of another will average about one month.

5. TIME OF YEAR WHEN THE FIRST WORMS APPEAR.

Until the investigation, of which this is only a preliminary report, was begun, our knowledge as to the earliest appearance of the worms was not only vague, but misleading. The statement emphasized by Professor Grote in the paper already referred to, namely, that the worm does not appear earlier than the latter part of June in the central portion of the cotton belt of Alabama and Georgia, very fairly echoes the prevailing popular belief on the subject; yet careful investigation the present season, and the collection of facts recorded in past years, show the statement to be essentially erroneous. The date of earliest appearance varies with location, and largely with the curves of isochimal lines;* it also differs somewhat in different years in the same location, according as the season may be late or early; and, lastly, it may differ to some extent in different parts of the same restricted locality, worms having been found just hatching in one place when, only a few miles distant, others were found nearly full grown.

While these modifying circumstances complicate consideration of the subject, it is easy to arrive at definite results by taking as a basis observations made at a few particular points during the present year. Hence I felt the importance of having such observations made the past spring in South Texas and South Alabama at those places where the worm was reported to have appeared earliest in past years. As a result, the fact is fully established that the first worms of the season may, and do, in ordinary years, hatch from the middle of April to the middle of May in the southern portion of the cotton belt. Indeed, it was this year observed so much earlier in Alabama than was formerly reputed that many journals announced the fact as very exceptional. Yet there are no good reasons to suppose the present year exceptional or abnormal in

* This is well illustrated by a fact communicated by Dr. D. L. Phares, of Woodville, Miss., viz, that the worm usually begins its work of destruction in Madison County from three to six weeks earlier than in Wilkinson; the former on latitude 33° and the latter resting on 31°. At Madison station, in the southern part of Madison County, the thermometer marked the extreme low temperature of —4° F. during the winter of 1878–'79, while at Woodville, only about two degrees farther south, the lowest temperature noted was 14° F., or a difference of 18°.

this regard. On the contrary, the facts all show that the season was a late one, for April frosts retarded the starting of cotton in those very sections of Alabama where the worms were first found; while it is the unanimous opinion of planters in South Texas, where the worms were first noticed, that cotton was from two to three weeks later in 1879 than usual. It will not surprise me, for these reasons, to learn in future that the first worms may be found even earlier than here stated.

In most cases of the first appearance of the worms, specimens were received and examined by me so as to leave no doubt as to their identity. In the cases observed by Mr. Schwarz the plants were from one to two feet high, not yet blooming and with all the leaves tender.

The first worms are always comparatively few in number and in isolated spots. They are, therefore, easily overlooked by all who do not take particular pains to search for them. From such spots as centers the worms multiply and spread in subsequent generations, with greater or less rapidity, according as the conditions are favorable or otherwise. Such increase and spread may be confined to some part of a given county until the cotton is nearly ruined before the cotton in the rest of the county is affected. The worms will then first appear in the remainder much more suddenly and numerously than they did in the former, the parent moths migrating thereto in bevies. As a rule, however, the spread in the southern portion of the belt is gradual and the worm in destructive numbers is preceded by one or more scattering generations in the same field.

Other things being equal, the worm must appear earliest in the southernmost latitudes, since extended observations on the appearance of other insects show that there is retardation of from four to seven days with each degree of latitude northward.*

There is, in normal seasons of little injury to the crop, a similar retardation northward in the appearance of the Cotton Worm within the southern portion of the belt, corresponding in some measure with the growth and development of the plant; and it is a notable fact that the worm is seldom noticed and never in great numbers before the plant begins to bloom. What is generally under these circumstances called the first brood or "crop" has been preceded by at least one and often two generations sparsely distributed over the fields. Yet in years when the worm abounds to a disastrous extent in the southern portion of the belt, its appearance in the northern or temporary portion cannot be counted on with any certainty as to time, because it is always the result of migrations in the winged state, and these migrations may be more or less extended according to circumstances. Between the first appearance of the worm in the southern and northern portions of the belt there is, therefore, a marked difference ordinarily observable, it being in the latter much later and in far greater numbers.

* *Vide* remarks on time of appearance of the Northern Army Worm and hatching of locusts. Mo. Ent. Report VIII; p. 47; 1st Rep. U. S. E. C., p. 232.

6. CONDITION OF SOIL AND PLANT CONNECTED WITH THE APPEARANCE OF THE FIRST WORMS.

Having seen that the worms first appear in parts of the southern portion of the cotton belt at a much earlier date than previously supposed, we will now briefly consider the conditions of soil and of the plant connected with this first appearance. In glancing over the reports on this subject in answer to my questions, I find a remarkable unanimity of opinion corresponding with what Mr. Schwarz has observed and with the general experience collected. It is that the earliest worms of the season are confined to fields on the "low lands" where the plants are naturally more thrifty and more advanced than on any other soil. Low lands where cotton is planted in Texas and Louisiana comprise the so-called bottom lands of the rivers, and on such lands the soil is always a very rich alluvium and never sandy. Farther east, however, low lands are frequently sandy and the bottom formation of alluvial soil is less common than in Texas and Louisiana. This holds especially true of Florida, where the soil is exclusively sandy, more or less mixed with decayed vegetable matter. In the latter State fields on "hummock land" and near the edges of ponds or lakes replace the bottom lands of Texas and Louisiana. The rule of the first appearance on such low, rich, and moist lands does not apply alone to the extensive area of such land in the southern portion of the belt, but also to similar low places in particular parts of plantations in the whole cotton-growing country, the first worms on any plantation always being noticeable in such low spots.

The general rule, however, is not without exception, for on the sea islands off the coast of Georgia and South Carolina, where, in former years, the worms always appeared early, the soil in which cotton was and is to a limited extent still cultivated cannot be called low land. All low parts on these islands are occupied by marshes, and are unfit for cultivation, and the soil of the cotton fields is what is termed dry hummock land. Again, Mr. Schwarz found a very early appearance in Lavaca County, in Southern Texas, where the country is several hundred feet above the river bottoms in the same latitude and consists of open and rolling prairies. The worms were observed there in a field situated on top of one of the highest hills, and they have been observed there at similarly early dates in past years. The soil is, however, of that rich black nature peculiar to one part of the South Texan prairies.

A second circumstance which, according to the unanimous reports of planters and observers, appears to necessarily accompany the early appearance of the worms is that the cotton plants must be in a well-advanced and luxuriant condition. The earliest worms are never known to appear in fields in which the growth of the plants has been retarded

from one cause or another, as, for instance, late planting, the attacks of plant-lice, overflow, poor, exhausted, or sandy soil, &c.

A third fact is worthy of mention in connection with this early appearance, viz: that in open countries, or in countries where the prevailing soil is low and rich, there is almost always a gin-house or other building, a hay stack or some other shelter near by where the moths have to all appearance hibernated. Of the five localities in South Texas where the first worms were observed by Mr. Schwarz last spring, three were in the immediate vicinity of gin-houses, with no other building, fence, or tree in the neighborhood. In the fourth a gin-house and other buildings, as well as trees, were close by; while in the fifth (that in Lavaca County, already mentioned) the nearest object which could have served for the hibernation of the parent moth was an open stable about one hundred yards distant, but covered with a thick thatch of hay.

In all cases observed or reported the first worms occupy but a limited patch in the field, and are not scattered over the whole field or over large portions of a plantation, as is the case with subsequent generations. The extent of this patch seldom exceeds two acres and sometimes does not embrace one-fifth of an acre.

Still a fourth circumstance connected with the appearance of the first worms is noticeable, and one that, as we shall see farther on, has much importance from the practical side. It is that they recur year after year not only in the same counties but also in exactly the same spots.

The condition of the plant has already been alluded to. In every case it was luxuriant, advanced, and vigorous. This condition of the plant has so much to do with the matter under consideration that there must be a cause for it, whether in the greater attraction for the moth possessed by such plants or the greater facility with which the eggs hatch or the worms develop upon the same; for when produced artificially by the use of manures and good cultivation, it may, and often does, have the same effect and counteracts the otherwise unfavorable condition of soil and location.

As throwing light on the subject and as a rational explanation of the facts, it is well to remember that the most advanced and luxuriant plants most copiously exude from the secretory glands the sweet fluid upon which the moths feed and by which, it is fair to presume, they are attracted; also that the moths' fondness for shade and moisture is gratified in such low places where the cotton is rank. These places are also just those where the dews are heaviest, and the facts which follow render it quite certain that moisture aids both the hatching and the development of the worm. Another suggestion may here be made that also helps in the explanation: the natural enemies of the worm, especially the ants, are less abundant in low, wet land than in that which is higher and drier. They will, therefore, be less efficient in destroying the young worms, which for this reason will stand a better chance of developing unchecked.

7. WET WEATHER FAVORS THE DEVELOPMENT OF THE WORMS.

In the foregoing pages we have seen that the insect both in its larva and perfect states has a predilection for low, moist ground, where the cotton is luxuriant. We may safely infer, therefore, that the meteorological influences that produce over large areas the conditions thus described for limited areas will prove favorable to the development of the worms; and, indeed, it is the uniform testimony and experience of all who have closely observed the facts that wet weather is favorable and dry weather unfavorable thereto.*

We have not to deal here with the cold rains that characterize the Southern winter, and sometimes occur as late as the beginning of May. The influence of this weather on the hibernating moth has not been definitely ascertained, but it is more than probable that, when occurring late in spring, especially if accompanied by a "norther," it may prove as injurious to the first generation of worms as it is known to be to the cotton plant. We have to deal rather with that broiling and humid state of the atmosphere consequent upon frequent showers and a clouded sky during the summer months or later. The earth may be said to steam and the air is full of vapor. The influence of such weather is twofold, viz, direct and indirect.

Its direct influences may, perhaps, best be illustrated by citing, in contrast, the effects of dry weather, which effects I have had an excellent opportunity of watching and studying the present year. As witnessed in the field, a large portion of the eggs during dry weather actually desiccate and fail to hatch. The worms are less active, and wanting in vitality; they drop more easily to the ground, and are so affected by the dry, heated surface that, in almost every instance, they fail to regain the plant. While vigor and vitality are thus impaired, the development during such weather is unduly hastened. The worms, for the most part, web up prematurely and fail to effect the change to chrysalis, generally dying in the act, half-worm, half-chrysalis. The chrysalides, in case the transformation was successful, show a great tendency to rot, while the moths, which hatch from the comparatively few that remain sound, find scarcely any food in the cotton field, as the glands, already described (p. 15), are almost entirely wanting in honey during very dry weather. Nourishment and fecundity being correlated, it is more than probable that the moths, poorly nourished, will lay fewer eggs under such circumstances. All the effects described are intensified and become most marked during extreme drouth, so that frequently at the end of a dry spell, such as is not infrequent in July and early August, not a worm can be found. A rainy season, following such a spell, will produce a

*Severe rains, especially those accompanied by gales of wind, such as occur occasionally in the South, especially during the autumnal equinox, have been known to kill the worms, beating them down and sweeping them into windrows and heaps. Such was the case in Mississippi in 1825, Matagorda County, Texas, on September 6, 1875, and in the Bahamas on October 1st, 1866. But in these and similar cases the destruction of the worms was always accompanied by the utter loss of the crop.

most noticeable change. Its effects are almost magical. The plants freshen up, and the moths simultaneously become active; their eggs hatch freely, and the worms are so voracious and active that they soon destroy the new leaves or "top crop" and then, of necessity, work on the older ones.

The effects of dryness as here described are equally noticeable when produced artificially. Experiments upon plants growing in the field, but inclosed in muslin-covered frames, have produced all the unhealthy conditions of the insect, simply because the covering prevented the normal precipitations of dew upon the plants; while in vivaria the injurious effects of a dry atmosphere have been equally noticeable. In the dry, hot air of the Bahamas the worms are reported as often dying from the heat in numbers on the plant; a fact which would indicate that our climate is more favorable to their welfare than that of those islands; for the worms seldom, if ever, die from excessive heat in this country, except as they fall upon the heated surface of the ground.

The indirect influences of wet weather, first pointed out by the writer last July in some remarks before the Mobile Cotton Exchange,* are even more potent in favoring the development of the worms. They consist in the comparative immunity which the pest enjoys during such weather from its numerous natural enemies, presently to be mentioned, all of which are prevented during wet weather from working with the energy and activity they display during dry weather. This holds especially true of birds and ants, the latter of which not only lie to their nests during such weather, but are often drowned in countless numbers in open fields during heavy showers. Few who have not carefully observed the facts can appreciate the results of the non-working, even for a few short days, of these natural checks to a species so remarkably prolific and quick of growth as our Aletia.

It may also be remarked in this connection that wet weather is unfavorable to the poisoning of the worms, and prevents the working of cotton, which working, as will be shown further on, also helps to destroy them.

8. NUMBER OF ANNUAL GENERATIONS.

The general impression and belief that prevails in the South is that there are, in those sections where the worm is most injurious, three broods or generations, or, as the planter puts it, "crops," each year. This statement of the case has also been accepted as correct by most previous writers on the subject.† It is, however, essentially erroneous so far as the Southern portion of the cotton-belt is concerned, as the earlier and later generations are not taken into account but overlooked. The appearance of the first generation has already been discussed (*ante*, p. 17), and it occurs during the latter part of April and in May in the

*See *Mobile Register*, July 10, 1879.

†Dr. Phares is the only writer who has, so far as I can learn, recorded as many as six generations from July 6, 1869, till frost.—(*Rural Carolinian*, I, p. 695.)

more southern portions of the belt. One generation follows another continuously from that time on just so long as there are any leaves to be devoured, and I have, by protecting both plant and insect from frost, kept the moths ovipositing in the city of Washington all through November; while the worms, under like conditions, have hatched through the early part of December, matured, and spun up about Christmas time.

Careful observations and experiments the present year in South Texas show that at least seven, and probably even more, annual generations are produced there. The first two generations are generally well separated, but, owing to the irregularity in egg laying and in individual development, the later generations so cross each other, that the insect may be found in all stages in the same field at one and the same time. This was particularly noticeable last summer from the middle of July on. Yet the succession of broods may be recognized by the condition of the bulk of the specimens in the field or by confining the insects for the better watching of them.

The first generation, as we have seen, is confined to spots. The second generation is more dispersed, but still restricted to areas in the vicinity of the hibernating centers. The third generation of worms may become, under favoring conditions, not only widespread but disastrous, and the moths produced from them so numerous that they acquire the migrating habit. This generation appears in South Texas during the latter part of June, and in South Alabama and Georgia somewhat later. This is usually the supposed first brood in those sections, *i. e.*, the first which attracts general attention. The subsequent generations naturally become more and more widespread, and the increase during last July and August was noticeable in the face of meteorological conditions unfavorable thereto. The worms during these months will appear in those fields in which they did not appear earlier, as on sandy, elevated prairies, soils or lands where the growth of the plant was retarded from late planting, overflowing, the injury of the plant-lice, or whatever cause. If the weather be favorable, this August generation will, when unmolested, carry ruin in its wake. Did one generation follow another in the natural ratio of multiplication, such is the fecundity of the species, that there would be no hope of profitably cultivating cotton. Fortunately for man, some of the earlier generations are liable to be so effectually kept in check by natural enemies and other adverse influences that they become innocuous and frequently escape notice. This fact was strikingly illustrated last May in Colorado and Lavaca Counties, in Texas, where the second generation which hatched in sufficient numbers in most fields to create alarm, nevertheless vanished before its enemies so completely, that it was difficult a little later to find a perfect chrysalis.

That this second generation may exceptionally become very injurious is shown from records, to the effect that in the early part of June, while the cotton-stem was yet tender, whole plantations in the low bottom

lands of Louisiana have been eaten to the ground; but that it more often proves harmless, as it did the present year, is probable for various reasons. The plant-lice, which are apt to be very numerous on the very young cotton, partially disappear before their natural enemies by the time this second brood of worms is developing. The ants, which were previously supplied with food by the plant-lice, have now multiplied, and are forced, by the decrease of the aphides, to seek other food. They are consequently more effectual in destroying the young worms. All the other enemies of the worm are also more active during the month of June, and gregarious birds, like the blackbirds and ricebirds, are very common during that month, but generally leave the fields later.

In the northern portion of the cotton belt the number of annual generations is, of course, fewer, and will vary according to the date of the incoming of moths from the further south, and according to other circumstances. The generations are not only fewer, therefore, but more easily separated and defined.

9. MIGRATIONS AND POWER OF FLIGHT OF THE MOTH.

Many persons, noting the short and clumsy though rapid and darting flight of the moth, when disturbed during the day-time, get the idea that it is incapable of extended flight. But it has great power of wing, and its migrating habits are abundantly attested. It has been observed in numbers, far out at sea, and captured in autumn off the coast of New England, around Chicago and around Buffalo—the species being identified by competent entomologists like Packard, Burgess, Grote and Westcott. I have known it to do considerable injury during September to peaches in Kansas, and to ruin acres of cantelopes during the same month as far north as Racine, Wis. That it is aided in these distant flights by favoring winds there can be no doubt, but that it does not depend on them for dispersion is equally certain.

Dr. D. L. Phares records the destruction by the worms, of cotton the first year planted, eighty miles from any point where cotton had been grown before; while Mr. H. P. Bee (see letter in Appendix) shows that they appeared in Mexico on cotton planted two hundred miles from any other fields. Numerous similar cases might be mentioned.

The migrating habit is common to many insects and other animals, but is almost always associated with excessive multiplication. Such is likewise the case with Aletia, as the observations of the past year have clearly shown. So long as the worms are not numerous enough to materially riddle the cotton, the moths produced from them busy themselves with ovipositing in the neighborhood where they were born, spreading only comparatively short distances on all sides; but whenever the cotton is well "ragged," then the moths acquire the migrating habit and appear in numbers everywhere—in town and village, and at lights far away from cotton-fields. The time of year when this migra-

ting habit is acquired varies, but it is rarely till after the third generation of worms or the latter part of June and fore part of July in South Texas; while it is most pronounced during the autumn months. At such times, the moths may be noticed, during cloudy days, starting off by rapid flight and ascending high in the air till lost to sight; and the contrast between this movement and the darting and hiding of the normal day-flight is quite striking to any one who has witnessed it.

10. HIBERNATION.

No question connected with the Cotton Worm has given rise to more speculation than that of the hibernation of the insect, and this fact at once finds its explanation in the difficulty that surrounds the subject.

As partly illustrating this difficulty it will be well to elaborate the statements made in a paper read by the writer before the National Academy of Science at its meeting in Washington last spring.

There are three principal theories on the subject that are worthy of consideration, and that are held by those with whom I have come in contact, or with whom I have corresponded. These are:—

1st, That it hibernates in the chrysalis state.

2d, That it hibernates as a moth.

3d, That it does not hibernate in any part of our cotton-growing States, but comes into them on the wing from warmer climates where the cotton-plant is perennial.

Some few persons think that it winters in the egg state in cotton-seed or on the dead stalk of the plant; but such views may be disposed of by the statement that they are unsupported by even the appearance of fact.

At first blush it would seem easy enough to dispel whichever of these theories is erroneous and settle the question under consideration by a few simple facts of observation. The trouble is, however, to get at the facts.

About one-fourth of the intelligent people of the South hold the opinion that this Aletia hibernates in the chrysalis state, some believing that it does so above ground, others that it retreats beneath the surface of the ground. It has generally been stated by the writers on this insect that the chrysalis could not endure the slightest frost. I have been able to prove that it will suffer with impunity a temperature of from five to ten degrees below the freezing point, but that it cannot withstand a lower temperature; and all those chrysalides which do not give out the moth before severe cold weather sets in perish beyond any doubt. How easily men are misled even on this point, however, may be gathered from the fact that Dr. E. H. Anderson, of Kirkwood, Miss., a most intelligent observer and experienced cotton-planter, kept what he believed to be living specimens until after the severe cold of December last. A careful examination proved that the lifelike motions of such chrysalides were due to the living pupa which they contained of one of the parasites

(*Pimpla conquisitor*) presently to be described. The larger proportion of chrysalides that are not empty after a severe frost has occurred are infested with some kind of parasite, though many of them have perished from the effects of the frost and are either rotten or mouldy.

Any number of intelligent planters insist that they plow up the chrysalides in spring, and the belief that the last brood works beneath the ground, out of reach of frost, is very firmly held by some of the most experienced cotton-growers; but in every instance that has come to my knowledge the chrysalides thus plowed up have proved to belong to other species, most of them of the same family, and many of them having a sufficiently close resemblance to those of Aletia to confound any but the most skilled and experienced entomologist. As an illustration of the ease with which erroneous conclusions can be drawn from mistaken identity, I will here quote part of a letter received last spring from Prof. J. E. Willet, one of our observers who has particularly interested himself in this subject. "I have received to-night," writes Professor Willet, "from Rev. Robert Harris, of Cairo, Thomas County, Georgia, a small tin box inclosing 25 chrysalides, which I forward you by mail. Mr. Harris is an ardent believer in the subterranean hibernation of the chrysalis of *Aletia argillacea*. I transcribe the portion of his letter pertinent to the case:

"'CAIRO, GA., *February* 22, 1879.

"'Washington's birthday and victory. *Perseverantia vincit.* The facts drive "analogy" to the wall. Here they are: 25 cotton-worm chrysalides ploughed up out of the ground in a field that was riddled by the insects last fall.

"'This is unimpeachable evidence, and in the opinion of the court is amply sufficient to convict the prisoner.'"

"The chrysalides," continues Professor Willet, "appear to my eye very like *Aletia* chrysalides which I have in spirits, and I await your verdict with interest."

The chrysalides referred to in this instance resemble those of *Aletia* so thoroughly in form, size, and general appearance that they might have been mistaken therefor even by some entomologists; yet, from certain minute structural differences, easily observable with a good lens, I was able at once to decide that they belonged to another insect, the *Aspila virescens* of Fabricius, a beautiful moth, with olivaceous primaries, marked with three distinct pale transverse lines, relieved by coincident deeper shades, the translucent green larva of which, speckled with minute pale fleshy elevations, I have found feeding on *Solanum sieglingæ* in Saint Louis.*

*I append a description of the larva of *Aspila virescens:*

Smooth, soft, translucent, with the normal complement of 16 legs. Color either green or lilaceous. Finely speckled, with pale yellowish spots (appearing under the lens as fleshy elevations), arranged in a somewhat longitudinal manner, and forming along the stigmatal region a tolerably well-marked band; the stigmata, which are in the upper portion of this band, being black, with a carneous center and white annulation. Piliferous spots in normal position, very small, dark, with a paler annulation; the hairs fine and translucent. The two posterior joints somewhat squarely cut off. Head, thoracic legs, and cervical shield polished and slightly more yellow than body.

Full grown in July; imago issuing in August of same year.

There are many species of night-flying moths which go through their transformations beneath the ground, and there hibernate in the chrysalis state. The leaves of the cotton-plant are palatable to a very large number of such, while the Boll-worm (*Heliothis armigera*) and the "Grass-worm" (*Laphrygma frugiperda*), which thus transform, are sometimes very abundant in a cotton field. It is not at all surprising, therefore, that the chrysalides should be plowed or dug up in land planted to cotton. All of them, upon careful scrutiny, will be found to differ from the chrysalis of Aletia, which may be distinguished by its slender form, and particularly by the tip of the body with its armature, as shown in Fig. 4, p. 13. In short, the nature of the Aletia chrysalis effectually prevents it from working beneath the ground, except where, dropping out of its cocoon, it happens to fall into some crack or crevice, and thus wriggle beneath the surface. It is also contrary to all analogy that a chrysalis normally found above ground in a cocoon should work beneath the soil; for all insects that pupate under ground descend while in the larva state.

Experiments which I have repeatedly made prove that the Aletia chrysalis, when placed under ground, either rots and perishes or the moth, if in a sufficiently advanced state when the chrysalis is buried, will vainly attempt to escape and push through its unnatural surroundings.

Regarding the ability of the moth to survive the winter, nearly one-half of the more intelligent correspondents state that they have known the moth to be found flying during warm days in the winter, and that it consequently hibernates in that state. Mr. John T. Humphreys, of Morganton, N. C., who was for awhile employed by the State of Georgia in entomological work, says that he has absolute proof of the hibernation of the moth.

Page after page of testimony and experience from the most competent and reliable planters might be adduced in support of the fact that the moth is to be seen either hidden in sheltered situations or flying during the milder weather of winter, and in spring, in all of the southern portion of the belt. The situation in which it is most often reported as sheltering are under the shingles of gin-houses, under rails, and under the loose bark and in the hollows of trees and prostrate logs. In old pine stumps the sap-wood separates from the heart-wood and forms excellent retreats for this purpose. The general hue of the large scales of pine bark is sufficiently close to that of the moth to make the resemblance protective. A dense forest of Long-leaved pines also modifies and equalizes the winter temperature. These facts would lead one to suppose that pine forests offer unusually favorable conditions for hibernation, and Mr. Humphreys has, in fact, found the moth hibernating under pine scales, while some of my most reliable correspondents report having seen the moths sporting in great numbers in the edges of pine forests during the month of March.

Nevertheless, the persistent search by Mr. Schwarz last winter,* under

* Mr. Schwarz traveled throughout the southern portion of the belt, and visited the Bahamas, with the special object of learning the winter quarters of the moth.

my direction, while yet connected with the Department of Agriculture, failed to reveal the moth under pine bark; whereby I was led to the conclusion that it seeks winter shelter some distance from the ground. It has been reported by some correspondents in greatest numbers in swamps of sweet gum, oak, magnolia, poplar, &c., such as are found in Southern Alabama. These swamps are warm, moist, and miasmatic, and the moths are said to have been seen literally packed together in a torpid state in the hollows and burrows made in rotting logs by boring larvæ.

The evidence on this point of the hibernation of the moth would be overwhelming did it come from scientific observers; but, unfortunately, allied species are so often and so easily mistaken for Aletia that doubt still surrounds the subject. The liability to confound hibernating species is all the greater in that characteristic markings are more or less effaced or faded. The *Hypena scabralis* (Fabr.),* a moth, belonging to a different family (*Pyralidæ*), and which hibernates in the imago state all over the country, is especially common in the Southern States, and large numbers have been sent to me as the genuine Aletia. It is nearly of the same size and form, and while normally of a darker brown, faded hibernating specimens are easily mistaken for the Cotton Moth because of undulating darker lines across the front, somewhat similar to those on the latter. Its palpi are longer and snout-like, and its front wings invariably lack the dark discal spot and the white specks (see p. 14) characteristic of Aletia.

Phoberia atomaris Hübn., and many other similar moths, have been forwarded with the remark that they were the Cotton Moth; while *Leucania unipuncta* Haw., the parent of the Northern Army Worm, which feeds only on grasses and cereals, is everywhere found in the South during winter, and, on account of its great similarity in color to Aletia and of a white discal spot relieved with a dark shade on the front wings that heightens the general resemblance, is more often mistaken therefor than any other. It is more robust than Aletia, and a comparison of the accompanying illustration (Fig. 8 with Fig. 7, p. 15) will show the other differences. Seeing how easily non-entomologists are misled by general resemblances, I would again lay stress on the readily-observed char-

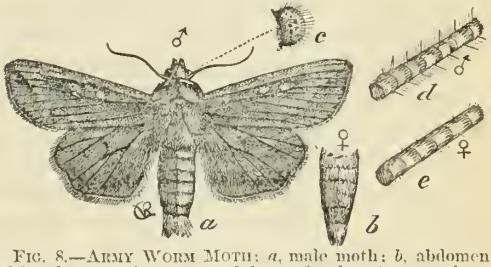


FIG. 8.—ARMY WORM MOTH: *a*, male moth; *b*, abdomen of female—nat. size; *c*, eye; *d*, base of male antenna; *e*, base of female antenna—enlarged. (After Riley.)

* The *Platyhypena scabra* (Fabr.) of Grote's List. Its larva is grass-green in color with a medio-dorsal and subdorsal lines of a darker green, the latter bordered below by a whitish line. It is cylindrical and with but three pairs of abdominal prolegs. It feeds on clover, and also on *Robinia*. The chrysalis is formed in some sheltered situation and surrounded with white silken threads; is dark and slender like that of Aletia, but the tip is armed with two strong, slightly diverging spines. In Missouri this chrysalis may be found under bark during winter, and it doubtless hibernates in both chrysalis and imago state in the South.

acters underlined on page 14, by which Aletia may always be recognized. Where they are absent it may be safely taken for granted that other species are in question. From this danger of confounding species it is evident that ordinary reports lose, when unaccompanied by specimens, much of their value, and must always be taken *cum grano salis.*

Yet, after making due allowance for possible error, the number of intelligent planters whom I have conversed with, and who, having long and thorough acquaintance with the moth, feel positive of their ability to distinguish it and of having seen it during the winter, is so great as to leave little doubt of the fact, while the added testimony of Professor Grote, who is such authority on moths that he could not thus confound species, and who states that he has found the *Aletia* in Alabama during mild winter weather, should dispel even that little doubt, and we may safely consider as proven that the moth does survive the winter up to the end of March. The general experience of correspondents is, however, that after March these hibernating moths are no longer to be seen, and no one knows what becomes of them between this time and the appearance of the first worms.

The difficulty felt in bridging this gap, together with the progress of injury from the south northward, has given rise to the theory that the species cannot survive the winter in this country, and must necessarily come each year on the wing from some exotic country where cotton is perennial. Mr. Robert Chisolm, of Beaufort, S. C., seems to have been the first to suggest the theory, but the first published statement of it that I can find is by a Mr. Gorham, who, in 1852, distinctly says:* "My speculations on the nature and habits of the cotton fly have led me to adopt the following hypothesis: That it is a native of tropical climates, and never can pass a single winter beyond them, consequently never can become naturalized in the United States, or anywhere else where the cotton plant is not perennial."

Two years later it was more fully set forth by Dr. W. I. Burnett† from facts communicated by Mr. Chisolm, and lastly it was again urged, as original, by Professor Grote, in 1874, in his paper, already cited (p. 8). Professor Grote's conclusions were "*that it dies out every year (with its food plant), that it occurs in the cotton belt of the Southern States, and that its next appearance is the result of immigration.*"‡

The principal arguments urged in support of the theory by Professor Grote are [1] the *sudden* appearance of the moth in quantities; [2] the first appearance of the worms so late as the latter part of June; [3] the

* De Bow's Industrial Resources of the Southern and Western States, 1852, vol. i, p. 169.

† Proc. Bost. Soc. Nat. Hist., 1854, vol. iv, pp. 316, 317.

‡ It was my privilege to follow the reading of this paper with some remarks expressing my general appreciation of it, but urging at the same time some qualifications of the theory, and the belief that the insect hibernated in the more southern portion of the belt. These remarks seem to have had some weight, for in the printed copy of the paper in the Proceedings of the Association a qualifying clause (not in the paper as read or as printed at the time in the New York *Tribune*) is added, admitting the possibility of hibernation in Florida and Southern Texas. Professor Grote based his views on an experience had in what is known as the central cotton belt of Georgia and Alabama. The exact northern or southern limits of this belt are not stated, but it includes most of the canebrake region of the latter

absence of parasitic checks; [4] the highly probable exotic origin of the species and its introduction into the States; and [5] the power of flight and migratory habits of the moth. The first three lose much of their force from the facts adduced in this bulletin, since [1] in the southern portion of the belt * the sudden appearance is more apparent than real; [2] the worms appear in April; and [3] they have numerous parasitic checks. There is also little force in the fact of original introduction from some foreign country, since most of our worst insect pests that are now acclimated and established with us were originally introduced from abroad; while [4] the migratory habit, as we have seen, is not developed in the first moths. Arguments urged by others in favor of the theory are [6] the periodical visitations and intervals of immunity; [7] the short life of the moth; and [8] the failure of those who have tried to keep it through the winter.

To these it may be replied that [6] many other indigenous insects abound during certain years and are unknown in others, and that these changes are due to the working of well known laws; that periodicity in the appearance of Aletia is largely imaginary, because it either refers only to bad years and takes no stock of small numbers, or else is local. The investigations of the Commission show that the worm has been in some parts of the South ever since the civil war, and there is no reason to suppose that it was not annually to be found in fewer or larger numbers prior thereto. [7] The short life of the moth of the summer generations is no criterion for that of the last or hibernating brood, since any number of species which produce several annual generations and have but a brief span of life in the imago state in summer are known to hibernate in this state. [8] It is extremely difficult to attain, in a room, the proper conditions of moisture and freshness that belong to a sylvan atmosphere, and I have never been able to keep other Lepidoptera which hibernate in the imago state alive through the whole winter in such artificial situation, though I have tried with both *Danais archippus* and *Paphia glycerium*. For this reason it will always be next to impossible to get *absolute and incontrovertible* proof of the hibernation of Aletia by watching the moths from Fall till they oviposit the following year, but it may be truly said that if the hibernation of other species rested on equally absolute proof, there is not one among the Lepidoptera, or other orders for that matter, that could be said to hibernate. One other argument that has been made in favor of the theory may lastly be mentioned. It is that during the late war no cotton was grown for three years in some sections of the South, and that the first crop raised thereafter was infested. Professor

State, and extends south of what, in a broader way, I have defined as the southern or hibernating portion of the whole cotton belt. The arguments against the theory of annual immigration are therefore based on experience gained, in great part, in the same latitude and regions referred to by Professor Grote. While yet connected with the Department of Agriculture, I directed Professor Grote to pay particular attention to this question of hibernation, and it is due him to state that his investigations in Southern Georgia, according to his report submitted, led him to admit the possibility of the moth's hibernating there, though as late as last January he was reported as having confirmed "his theory" that "the fly comes from the West Indies with the south winds every year."—(*Pop. Sci. Monthly* vol. xiv, p. 406.)

*Roughly defined in the Introduction.

Comstock took particular pains to make inquiries on this head, and found that some patches of cotton had been grown every year in such sections.

In favor of hibernation in the southern portion of the cotton belt may be urged [1] the appearance of the moth on the wing during mild winter weather, and its being found torpid in sheltered situations, as is insisted on by so many; [2] the first appearance of the worms in very small numbers, and in the spring of the year, as attested by recent observations; [3] their reappearance each year in the same spots, not on the sea-coast nearest to the tropical zone, where we should expect them on the theory of annual incoming, but at various points far inland; [4] the coming of the moths in large numbers and as immigrants into the northern portions of the belt, being always preceded by the appearance of the worms and their gradual increase at some other, generally more southern or western, points; and [5] the decrease of cotton culture in Central America and the West Indies, as appears from market statistics, and the absolute absence of the worm in the Bahamas since 1866, as ascertained by Mr. Schwarz while there last spring.

The strongest fact against hibernation is, perhaps, the period elapsing between the disappearance of the moths in March and the first appearance of the worms, or, to put it in another form, the absence of the worms on the young and tender cotton. The period during which the species is not to be seen is already reduced by the facts given in this bulletin to less than one month instead of three, and this is much less than the time elapsing between the issuing from winter quarters of other well-known Lepidoptera that hibernate in the imago state, and the first appearance of their larvæ, numerous illustrations of which fact might be cited.

On the whole, therefore, the weight of evidence is strongly against the theory of annual extermination, in the southern part of the belt, and the fact of the hibernation of Aletia there may be said to rest on as good evidence as that of many other species in which it is admitted without question. Yet Aletia is beyond doubt killed out each winter in the northern portion of the cotton belt, and all the arguments in favor of annual extinction and incoming *de novo* have force when restricted to this section. Just where the separating line lies between extinction and survival is not so easy to decide, and for the present I can only refer to that given in the Introduction as the result of the investigation so far as it has gone. This conclusion that the moth does and can hibernate in the United States does not preclude its occasional incoming from foreign, more tropical countries, or the possibility of its being brought by favorable winds from such exterior regions, just as originally must have been the case when the species was first introduced. The facts indicate, however, that this kind of immigration is less frequent now-a-days than it was in the beginning of the century.

To sum up the evidence from present knowledge: Aletia never hibernates in either of the first three states of egg, larva, or chrysalis, and it survives the winter in the moth or imago state only in the southern portion of the cotton belt. My own investigations during the past two

years in every cotton-growing State in the Union, except South Carolina and Florida (which have been visited by Mr. Schwarz), together with the experience and testimony of both correspondents and special agents employed in the investigation, confirm me in these conclusions, and I will close the discussion with two other suggestions that grow out of this experience.

1. It is quite certain that by far the larger portion of the moths from the last brood of worms perish in various ways without perpetuating the species. All those which fly north of the cotton belt must needs thus perish, as doubtless do all those that attempt to hibernate in the northern portion of said belt. The evidence is strong that even in the hibernating portion of the belt only the exceptional few, more favored than the rest and remaining steadily torpid till early spring, survive to beget progeny. Those which are aroused to activity during the mild winter weather spend their force without finding compensating nourishment, as there are neither fruits, flowers, nor sweet-secreting glands at that season wherewith to break their long fast and sustain vitality. It is for these reasons that the worms are generally less injurious after mild and changeable winters and most to be dreaded after severe and steady ones, and it may very justly be argued, that did the larger proportion of the moths survive, there would be no chance to grow cotton. Like perishing of the bulk of most insects that hibernate above ground is, in fact, an acknowledged rule in entomology.

2. The localities where Aletia doubtless hibernates, and where, consequently, the earliest worms appear, seem to be more common in the western parts of the cotton belt than in the Atlantic States. Since the civil war the almost complete abandonment of cotton cultivation on the sea islands of the coast of Florida and Georgia has evidently reduced the number of favorable hibernating localities there, and in so far protected the more northern or western portion of the Atlantic States from the immigration of the moth from those quarters. In Texas, on the contrary, the cultivation of cotton has been constantly increasing since that time, and consectaneously the number of hibernating points and the risk of serious harm there over extended areas have also increased.

11. NATURAL ENEMIES.

We have already seen that meteorological conditions may favor or retard the multiplication of the Cotton Worm, but that their influence is, in a great degree, indirect, *i. e.*, by favoring or retarding the work of the insect's natural enemies. Careful observations in the field for a single season will convince any one that these natural enemies are far more numerous than has hitherto been supposed, and that without their aid man would be powerless in his efforts to cope with an insect with such powers of multiplication as Aletia possesses. While it will be well to treat here with some fullness of the true parasites of the species, because they have been so generally overlooked, I shall pass the other

enemies with a bare indication of those that have been so far observed. The list will no doubt be greatly extended by future observations. I am strongly inclined to believe that the first generation of worms is less subject than later generations to the attacks of their worst enemies—birds and ants. The former are apt to overlook the few spots where the first worms appear, while the latter are too busy at that early season with the plant-lice which then abound. The converse will hold true of many of the true parasites, and the first worms are doubtless sometimes entirely extirpated by them.

Those who have carefully watched the worms in any given spot have been struck with the sudden disappearance from day to day of a certain proportion of them. This apparently mysterious disappearance is admirably set forth in the experiments made by Professor Willet with the yeast fungus, and quoted farther on. It frequently puzzled and baffled Mr. Schwarz in his efforts to watch the worms on certain special plants, and there can be no doubt that it is due mainly, if not entirely, to the efficient work of natural enemies, especially those that are nocturnal.

VERTEBRATES.

Among quadrupeds the Cotton Worm has few enemies of importance. Hogs are rather fond of it as attested by many planters. The Raccoon is also reported to have been seen eating the worms from the plants, and breaking these down in doing so. The Skunk and the Opossum have also been known to feed upon it. These animals can do little good except where the worms are in such large numbers that they travel over the ground and from field to field. Bats devour large numbers of the moths, and, in favorable localities, may be seen at evening time dashing over the cotton fields in pursuit of them.

Birds are of incalculable benefit, and it is probable that most of the insectivorous birds which prevail in the South feed at times on the species either in its larva, chrysalis, or moth state, but only those which have been observed to do so will here be mentioned.

All domestic birds as turkeys, chickens, guinea fowl, and geese are fond of them, and may be employed with benefit. Turkeys are the most efficient, but they get demoralized when locusts or grasshoppers are abundant, by running after these, which they greatly prefer to the worms. Prairie chickens and quails often do good work in devouring the worms, while a Thrush (probably *Harporhynchus rufus* L.), the Rain Crow or Cuckoo (*Coccygus americanus* Bon.) Bluebird (*Sialia sialis*), Cardinal Grosbeak (*Cardinalis virginianus* Bon.), Mocking-bird (*Mimus polyglottus* L.), Blue jay (*Cyanurus cristatus* Sw.), Red-wing blackbird (*Agelæus phœniceus* Vieill.), Rice bird (*Dolichonyx oryzivorus* L.), and Killdeer plover (*Aegialitis vocifera*), are more or less persistent in feeding upon them. The domestic birds and some of the wild species may be attracted to a field by scattering a little corn or other grain on the ground. The most effective help to man is rendered by the gregarious species such as the Rice birds and Blackbirds, and they have protected and saved fields near their favorite resorts or resting-places. The Rice

birds occur in large swarms only in the vicinity of swamps; the Blackbirds are more generally distributed, but unfortunately they nearly all migrate northward in June from those localities which are most exposed to the attacks of the worms, and they seldom return again till after frost. It is quite amusing to watch how deftly they will extract the chrysalis from its leafy or silken covering. Of nocturnal birds, several, and among them the Night-hawks (*Chordeiles*), are supposed to feed on the moths, but the proof is necessarily difficult to obtain except by shooting and examination of their stomachs, and I cannot find that this has been done.

The introduction of the English Sparrow has been recommended by several writers. The experience so far had with it would indicate that little good is to be expected in this direction. A number were obtained from New York and let loose in 1870 at Macon Station, Ala., but did not colonize, while in Texas they seem unable to endure the intense summer heat, for, while they are found below latitude 30° in winter, they migrate north during the hotter months, or just when they would be most useful in the cotton field. It must also be borne in mind that this bird, except during the breeding season, is more graminivorous than insectivorous.

Of reptiles one meets an occasional tree-frog (genus *Hyla*) upon the plants, and these little creatures doubtless take their share of the worms. Other frogs, and reptiles generally, are extremely scarce in cotton fields.

INVERTEBRATES.

These consist principally of Hexapods or true insects, though some spiders (*Arachnidæ*) presumably assist, certain species of *Phalangium* and *Epeira* being frequently found on the plants. One species has often been seen devouring the worms, and deserves especial mention because of its frequency in all the States, except Florida, where Mr. Schwarz did not find it. This is the *Oxyopes viridans*, of Hentz, a beautiful, slender and green species. The notion, prevailing in some parts of the country, that this spider is confined to the cotton plant, is incorrect, as the species is also found abundantly on weeds, especially in moist places.

Predaceous Insects.

Of true insects which, from their well-known carnivorous propensities, might with safety be placed among the natural enemies of the Cotton Worm, there are a very great many, especially among the Coleoptera and Heteroptera; but I shall refer only to those which have been actually observed to feed upon them; and then note some of the species commonly found in the cotton field, and which presumably have the same habit.

HYMENOPTERA: WASPS, ANTS, &c.—In this order none are of greater importance than the ants. A careful observer, while going through any cotton field the latter part of summer, has no difficulty in observing the ants occupied in destroying the eggs of Aletia, or still more frequently in attacking the young worms that are helpless while in the act of molting, or in devouring the interior of the still more helpless chrysalids. Even old worms which, from cause whatsoever, once get to the ground, are almost sure to fall a prey to these persistent and voracious little animals; the writhings, jerkings, and jumpings of the worm being of no avail against the constantly increasing numbers of the enemy that come to the attack. Attractive as is the honey from the glands of the cotton plant to the Cotton Moth, it seems to attract few other insects, and even the ants, that have such a predilection for sweets, are only occasionally found partaking of it. The universal presence of ants on the cotton plants, and of their nests in the ground at the base of the plants, seems largely due to the similarly universal presence of the cotton plant-lice.

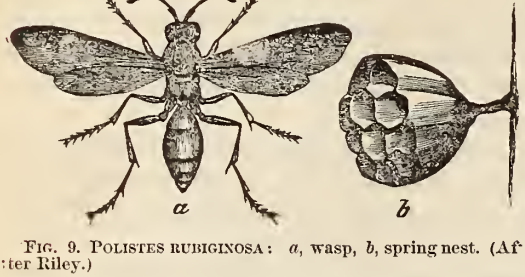


FIG. 9. POLISTES RUBIGINOSA: *a*, wasp, *b*, spring nest. (After Riley.)

The ants are always to be seen busily occupied in obtaining sweets from these *Aphides*, while but few are noticed to be sucking the liquid secreted by the glands. Now the plant-lice rapidly decrease in number with the advance of hot weather, though they never disappear entirely from the plants. The ants, as summer advances, are thus deprived of a large portion of their principal food-supply, and as their colonies become more and more numerous with the progress of the season, they are obliged to seek other food. It is but natural, therefore, that they should fall to preying on the Cotton Worm. It has already been mentioned that rains hinder the working of the ants, and that storms destroy them. They will, therefore, prove most effectual in assisting man where they are most protected from heavy showers, as on new land where the soil is uneven, or in fields where there are stumps, trees, &c. The species concerned in the good work differ with locality, and are reserved for future study.* The Leaf-cutting ant (*Oecodoma ferens* Say), when it invades a cotton field makes a clean sweep of every worm or chrysalis, but it also ruins the plant, taking off leaves, blossoms, bolls, and tender stalks.

*The most common and effective species in the Southwest is the *Solenopsis geminata* Fabr., a small species averaging 2.8^{mm} in length, and of a pale fuscous color, with a darker, piceous abdomen; another is *Dorymyrmex insanus* Buckley, var. *flavus*, both kindly determined by Rev. H. C. McCook. Among the DORYLIDÆ is *Labidus Harrisii* Hald., and *L. Melsheimeri* Hald., as determined by Mr. E. T. Cresson.

While I have repeatedly seen the first-named species attacking worms that were upon the ground, I have but once, at Macon Station, Ala., witnessed it feeding on a young worm on the plant; but so many correspondents have witnessed the good work of ants (and it has been confirmed by both Professor

Certain Paper-wasps (genus *Polistes*)* and Digger Wasps (genus *Sphex*)† occasionally carry off a worm; but beyond these and *Vespa germanica* no other Hymenoptera have been observed or reported.

COLEOPTERA, OR BEETLES.—Of this order numerous species belonging to the families of Tiger-beetles (*Cicindelidæ*) and Ground-beetles (*Carabidæ*) have been observed to prey upon the worms, each species being represented by but a very small number of specimens when compared with the ants. These beetles are nevertheless among the most voracious insects known to us. Most of them are nocturnal in their habits, and are thus more apt to escape the attacks of birds. They devour their prey bodily, and as they are frequently met with in cotton fields very remote from their hiding places, they are probably attracted by the smell attending the worms. The following is a list of the species actually observed feeding thereon:‡ *Tetracha carolina* (Linn.), *T. virginica* (Linn.), *Cicindela circumpicta* Laf., *Helluomorpha laticornis* (Dej.), *H. texana* Lec., *Galerita atripes* Lec., *Brachinus* sp., *Aphelogenia furcata* (Lec.), *Callida decora* (Fabr.), *Loxandrus lucens* Chaud., *L. crenatus* Lec., *Pterostichus Sayi* Brull., and *Sclenophorus læsus* Lec. In the larva state these beetles inhabit the ground, and cannot affect the Cotton Worm. A number of different Lady-birds (*Coccinellidæ*), and especially the small obscure species with flocculent or cottony larvæ, belonging to the genus *Seymnus*, are constantly found on cotton, but I have never been able to satisfy myself that they prey either in the beetle or the larva state on cotton worms; nor have any of the observers of the Commission obtained proof that they do. The natural food of these beetles consists of the plant-lice, to the increase of which they form the principal check. Soldier-beetles (*Telephoridæ*) and "Fireflies" (*Lampyridæ*) are also quite common on cotton, especially *Chauliognathus pensylvanicus* (Fig. 13), and their larvæ are well known to be predaceous; but these have not yet been found attack-

FIG. 10.—TETRACHA VIRGINICA.

FIG. 11.—CICINDELA.

FIG. 12.—CONVERGENT LADYBIRD: *a*, larva; *b*, pupa; *c*, beetle. (After Riley.)

FIG. 13.—CHAULIOGNATHUS PENSYLVANICUS: *a*, larva; *b*, enlarged head of same; *c-h*, mouth parts of same; *i*, beetle. (After Riley.)

Comstock and Mr. Schwarz), that there can be no question as to the general correctness of the above conclusions, though it is doubtful whether a worm is ever attacked by ants except when, from the causes mentioned, it is exceptionally helpless. Again, some species of ants are more ferocious than others, and they will act differently in different localities; hence there is a difference of opinion among planters as to their influence, and Dr. Phares does not believe that they accomplish much good.

* *P. rubiginosa* St. F. and *P. bellicosa* Cress.

† *S. cærulea* De Geer, *S. pensylvanica* Linn and an undetermined species.

‡ Species of the following genera have been observed by Mr. Schwarz on cotton plants at night, but they were not seen feeding on the worms: *Clivina* and allied genera, *Loxopeza*, *Lebia*, *Agonoderus Anisodactylus*, *Platynus*, and *Harpalus*.

ing Aletia, while the beetles are pollinivorous. A number of other beetles, as, for instance, *Collops quadrimaculatus* (Fabr.), having carnivorous habits, are found upon the plant, and may by further observation be added to the enemies of Aletia, while a minute yellowish-brown species (*Sericoderus flavidus* Lec.), belonging to the *Corylophidæ*, has been found feeding on the forming chrysalis while yet soft and helpless.

HETEROPTERA, OR HALF-WINGED BUGS.—Next to the ants in usefulness as natural checks are sundry species of rapacious or Soldier-bugs, as they are popularly called. These belong exclusively, so far as observed, to the families *Cydnidæ*, *Anthocoridæ*, *Scutelleridæ*, and *Reduviidæ*. They suck out the juices of their prey by means of a short but sharp beak, and the young have precisely the same habits as the mature insects, though often differing greatly in appearance. They are almost all active during the day, but a few work also at night. The species actually observed destroying cotton worms are: *Podisus cynicus* (Say), *P. spinosus* (Dall.), *Euschistus fissilis* Uhler, *Proxys punctulatus* (Beauv.), *Prionotus cristatus* (Linn.), *Apiomerus crassipes* (Fabr.), *Phymata crosa* (Linn.), *Melanolestes picipes* (H. Sch.), *Stenopoda cinerea* Lap. Also the following species, new to my cabinet, and kindly determined by Mr. P. R. Uhler, of Baltimore: *Oebalus pugnax* (Fabr.), *Repipta taurus* (Fabr.), *Aceratodes cornutus* Burm., and *Zelus bilobus* (Say). The following species, commonly found in cotton fields but not yet actually observed to feed on the worms, may safely be regarded as having the habit, while several others might be added, some of which combine the carnivorous with the plant-feeding trait: *Stiretrus fimbriatus* (Say), var. *diana* (Fabr.), *Euschistus punctipes* (Say), *E. tristigmus* (Say), *Thyanta custator* (Fabr.), *Rhaphigaster hilaris* (Say), *Sinea diadema* (Fabr.) (Fig. 16), *Metapodius femoratus* (Fabr.), *Evangorus viridis* Uhler, *Merocoris distinctus* Dall., *Anasa armigera* Say, *Nezara pensylvanica* De G., and *Triphleps insidiosus* (Say).

FIG. 14.—PODISUS SPINOSUS: *a*, enlarged beak; *b*, bug, with right wings expanded. (After Riley.)

FIG. 15.—PODISUS SPINOSUS: *a*, pupa; *b*, larva; *c*, egg. (After Riley.)

FIG. 16.—SINEA DIADEMA. (After Riley.)

FIG. 17.—STIRETRUS FIMBRIATUS. (After Riley.)

DIPTERA, OR TWO-WINGED FLIES.—In this Order the only species that attack the worms, and probably the moths also, belong to the *Asilidæ*, a family of large, fierce flies that pounce upon other insects as a hawk pounces upon other birds, and suck their substance by means of a strong beak. But two

FIG. 18.—PROCTACANTHUS MILBERTI. (After Riley.)

species—one the *Proctacanthus Milberti* Macq., Fig. 18, the other an undescribed *Asilus*—have been seen destroying the worm so far, though several belonging to the above-named genera and to *Promachus*, *Erax*, and *Laphria* are not uncommon in cotton fields.

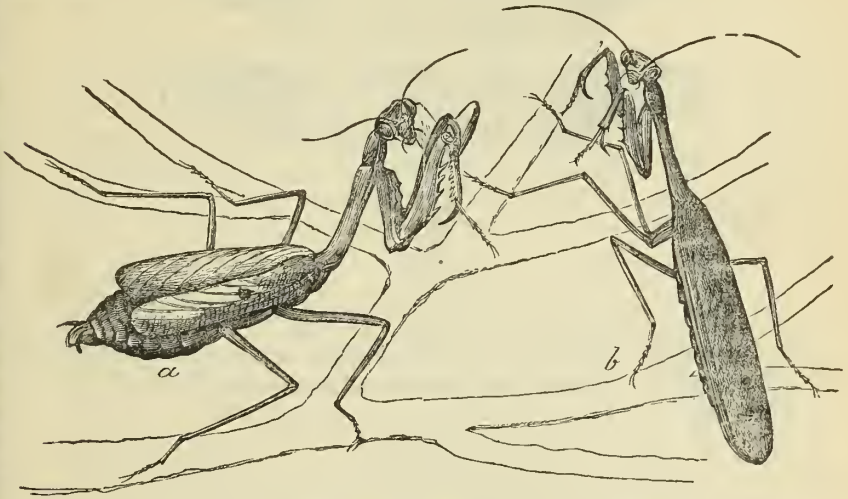


FIG. 19.—MANTIS CAROLINA: *a*, female; *b*, male. (After Riley.)

ORTHOPTERA, OR STRAIGHT-WINGED INSECTS.—The Carolina Mantis (*Mantis carolina* L., Fig. 19) is also occasionally found in such situations, and being purely predaceous, may be presumed to take an occasional Cotton Worm, though I have not yet seen it do so.

NEUROPTERA, OR NERVE-WINGED INSECTS.—The only species of this Order that are likely to prey upon Aletia belong to the Ant-lions (*Myrmelionidæ*), the Lace-wings (*Hemerobiidæ*), and the Dragon-Flies (*Libellulidæ*). The Ant-lions work in the larva state in pits in the ground and the constant plowing thereof will always prevent them from doing any material good, and they are naturally scarce. The Lace-wings are numerous, but their larvæ feed, like the lady-birds, on the plant-lice, and have refused to touch cotton worms when confined in boxes with them. The curious eggs of these flies, attached to the end

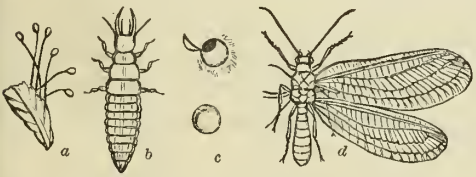


FIG. 20.—CHRYSOPA: *a*, eggs; *b*, larva; *c*, cocoons; *d*, fly with left wings detached. (After Westwood.)

FIG. 21.—CHRYSOPA with eggs.

FIG. 22.—MYRMELEON.

FIG. 23.—MYRMELEON LARVA.

of a delicate filament (Fig. 27, *a*), are often supposed to be those of Aletia. The Dragon-flies or Mosquito-hawks are aquatic in the larva state, but

FIG. 24.—LIBELLULA TRIMACULATA. (After Packard.)

the perfect insects are active in their pursuit of prey while on the wing, and are reported on good authority to attack Aletia both in the worm and moth states.

Parasites.

It has very generally been believed that no true parasites were known to affect the Cotton Worm, and this belief has been used by Professor Grote, as we have already seen, as an argument in favor of the arrival of Aletia *de novo* from some exotic country whenever it appears with us. The belief was founded on the fact that no parasite had been recorded by name so as to be recognized by entomologists. Yet, as the sequence will show, two species at least have long been referred to without identification as infesting the chrysalis, a fact overlooked by myself and other entomologists, but which I became aware of as soon as I commenced to collect chronological data while yet in the Department of Agriculture. The list of true parasites had, however, been greatly extended prior to my leaving said department, and some of the species are quite effectual in destroying Aletia, especially during the latter part of the season.

Infesting the Egg.—*The Trichogramma Egg-parasite:* Attacking *Aletia* in its earliest stage, the unhatched egg, this winged atom must be, when abundant, a most effectual check, and the scarcity of the Cotton Worm in certain seasons may doubtless be partly ascribed to its work. It is at least known that a similar egg-parasite has in the New England States relieved the shade trees from the ravages of canker-worms—a good deed which the European sparrows, notwithstanding they received the credit for it, were unable to accomplish. The *Trichogramma* is a yellow fly, so small that were it not for its activity in jumping it could not be distinguished by the unaided eye as an animated being, and it finds sufficient nourishment in a single egg of the Aletia to support its growth and maturation. It emerges from a round hole which it gnaws through the egg-shell, and eggs infested by it or which have been destroyed by it may be recognized by their bluish or blackish color and the presence of this perforation. When examined under the microscope,

the perfect fly is found to be an object of much beauty, the hairs upon the wings being arranged in regular lines. Some specimens of both sexes—the ♂ may be distinguished by the bristly antennæ—were found to have one or more of the wings imperfectly developed, presenting the appearance of a paddle. I append a description for the benefit of the scientific reader:

TRICHOGRAMMA PRETIOSA Riley (*Can. Ent.*, vol. xi, p. 161).—Length about 0.3mm. Yellow, the eyes red, the wings hyaline. Head wider than the thorax; antennæ five-jointed, joints 3 and 4 in the ♀ forming an ovate mass, and together shorter than joint 2; joint 5 large, thickened, and very obliquely truncate; in the ♂ joints 3, 4, and 5 form a more or less distinct elongate club, beset with long bristles. Hairs of the wings arranged in about fifteen lines. Abdomen not so wide as the thorax, but as long as the head and thorax together; in the ♀ the sides subparallel and the apical joint suddenly narrowed to a point.

Differs from *Trichogramma minuta* Riley (Third Rep. Ins. Mo., p. 158, fig. 72, ♀) in its smaller size and uniform pale yellow color, and also in the form of the third and fourth joints of the antennæ. As defined, and figured by Westwood (Intr. ii, fig. 77_{79}), the antennæ of *Trichogramma* are six-jointed. Walker, in his "Notes on the Chalcidiæ," pt. vi, p. 105, employing Förster's characters, says the antennæ are eight-jointed; but an examination of the figure of the type (*Trichogramma evanescens*, l. c., p. 114) shows that one of the joints counted is the "annulus" above the scape, which I do not consider to be a true joint, and that what I have indicated as the apical joint, in agreement with Westwood, is represented in that figure as three coalesced joints. I have proposed the generic name of *Pentarthron* for *minuta* (*Rec. of Am. Ent.*, 1871, p. 8), but *Pentarthrum* has been used by Wollaston for a genus of beetles, and until the allied genera are better characterized than at present, it is best to use the old genus *Trichogramma*, in all absolute characters of which *pretiosa* agrees.

This minute creature was first noticed by Professor Comstock in 1878, near Selma, Ala., and during the month of October last I found it quite common in Mississippi, Alabama, and Georgia, fully one-fifth of the eggs in some fields being infested. It is an interesting fact that an allied species infests the larva of an *Aleurodid* quite commonly found on the same leaves with the eggs of *Aletia*, and often mistaken therefor.

Infesting and issuing from the Worm.—*Two-winged flies:* Two species of flies belonging to well known parasitic genera have been found to infest the worm. One of these is the common Flesh-fly, and a male specimen bred from Aletia does not differ* materially from small specimens obtained from the decaying insects found in the pitchers of the spotted pitcher-plant (*Sarracenia variolaris*), and to which I have given the name of *Sarcophaga sarraceniæ*.

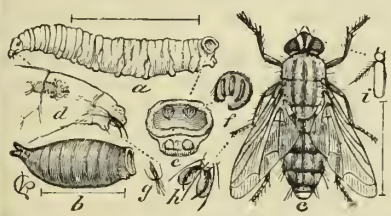


Fig. 25.—SARCOPHAGA SARRACENIÆ: *a*, larva; *b*, pupa; *c*, fly, the hair-lines showing average natural lengths; *d*, enlarged head and first joint of larva, showing curved hooks, lower lip (*g*) and prothoracic spiracle; *e*, end of body of same, showing stigmata (*f*) and prolegs and vent; *h*, tarsal claws of fly with protecting pads; *i*, antenna of same. All enlarged. (After Riley.)

These flies (Fig. 25) lay elongate and delicate eggs, which hatch very quickly. They sometimes hatch, in fact,

*Except in lacking the two bristles at the apex of the third segment of the abdomen which are prominent in *sarraceniæ* (type), and in other species, the specimen differs in no respect from those found to infest the Rocky Mountain Locust and *Caloptenus differentialis* (Locust Plague, etc., pp. 135–136; and First Am. Rep. U. S. Ent. Comm., p. 324). Although in the works here cited *sarraceniæ* is considered

within the oviduct, so that the fly gives birth to living maggots. The maggot penetrates the skin of the worm or the chrysalis, as the case may be, and feeds upon the fatty tissues within, acquiring full growth and issuing sometimes before but usually after its victim has transformed to the chrysalis state. Dropping to the ground, it burrows beneath the surface, and rapidly contracts to the pupa state, from which the perfect fly in due time issues. The species has been obtained from the Cotton Worm in Alabama, Georgia, and Texas, and is indeed widespread over the country. It is most abundant in autumn, and passes the winter in both the pupa and fly states. From the known preference of this fly for decaying or putrescent flesh, it is probable that the female is attracted more to diseased or injured chrysalides than to vigorous worms.

The other fly belongs to the genus *Tachina*, and appears to be an undescribed species. It measures about one-third of an inch in length, and is more robust and slightly larger than the common house-fly, from which, as well as from the *Sarcophaga* (which is less robust than the *Tachina*), it may be distinguished by having the bristle of the antennæ smooth and not hairy. These *Tachina* flies are more completely parasitic than the flesh-fly above mentioned, and their eggs are harder, more polished, and very firmly attached to the worm, usually just behind the head, where they cannot be molested. The larvæ or maggots have the same habits and mode of transformation as those of *Sarcophaga*, and the accompanying figure (Fig. 26) of *Tachina flavicauda* Riley, will serve to illustrate the flies. Occasionally these maggots are not full fed, and do not destroy the Aletia till after it has assumed the chrysalis state, but ordinarily they issue from the worm itself, which is frequently infested by more than one. The species was reared from chrysalides sent by Professor Grote from Savannah and by others from various parts of the South, including the States of Alabama, Mississippi, and Texas. I append a description:

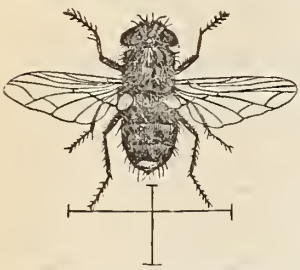


FIG. 26.—YELLOW-TAILED TACHINA-FLY. (After Riley.)

TACHINA ALETIÆ Riley (*Can. Ent.*, vol. xi, p. 162).—Length 8mm. Black; head golden, facial depression silvery, space between the eyes and the frontal stripe about

a variety of the common European *S. carnaria* it seems best to maintain it as a distinct species in accordance with the characters given by Mr. R. H. Meade, who, in his "Monograph upon the British species of Sarcophaga or Flesh-fly" (Ent. Mo. Mag., vol. xii, p. 216 ff., Febr.-May, 1876), separates the species into two principal divisions, according as the tip of the abdomen is red or is black or gray. In a note published in Baron Osten Sacken's Catalogue of the Described Diptera of N. A., 2d ed., p. 257, Mr. Meade says: "There is no specimen in your collection, however, exactly like the true *S. carnaria* so common in Europe. There are some striking points of difference between the *Sarcophagæ* of America and Europe generally, the chief of which is that in the former species with one or both anal segments red or yellow predominate, while among the latter, those with the anal segments black or gray are more numerous than those with the red."

The following additional specific characters may be added: Thorax with four bristles behind the suture in the two dorsal rows, the two anterior bristles small, the two posterior strong; in front of the suture are two small bristles alternating with two of slightly larger size. There are no minute spines on the second longitudinal vein similar to those on the fourth. The posterior tibiæ of the ♂ are loosely bearded on the inner side with long soft hairs. The second abdominal joint is not armed with strong central spines, and the spines at the apex of the third joint are short and weak.

equal to the breadth of the stripe, bristles of the head black, the pubescence behind and beneath the eyes white; antennæ blackish, palpi testaceous. Eyes at a moderate distance apart, thinly pubescent; front moderately prominent; third joint of the antennæ three or four times the length of the second joint. Thorax and the second and following abdominal joints more or less ashy, the thorax with four or five longitudinal black stripes. Wings subhyaline. Legs black, with a piceous tinge; tarsal cushions yellowish. Scutellum and the sides of the first, second, and third abdominal joints sometimes tinged with reddish-brown. No strong bristles on the first and second abdominal joints above.

A second species belonging to this genus has been bred from Aletia the past summer by Professor Comstock and referred to me, and others will doubtless be discovered. The reader interested in the minute differences that separate the maggots of these two genera, *Sarcophaga* and *Tachina* which similarly affect the Cotton Worm, is referred to the following comparisons:

The Tachinid *larva* differs from that of *Sarcophaga* in the following characters: It is of a paler whitish color, the skin being softer or less chitinized; the body is less narrowed anteriorly; the prothoracic spiracles are less apparent; a pair of spiracles are present on the posterior border of the fourth joint behind the head, which are not discoverable in *Sarcophaga;* the joints are not conspicuously wrinkled transversely and there are no lateral prominences, the anterior portion of each joint being prominent and roughened with minute points; the spiracular cavity at the end of the body is more shallow, the spiracles being exposed upon the obliquely truncated area; and there are no anal prolegs. The Tachinid *puparium* may be readily distinguished from that of *Sarcophaga* by the obsolescence (or in some species entire absence) of the prothoracic spiracles so prominent in *Sarcophaga*, and the absence of a cavity for the anal spiracles, both ends of the body being quite uniformly rounded.

Barthélemy has described the larva of *Senometopia atropivora* (*Ann. Sc. Nat.* 4e ser., vii, p. 115), while Laboulbène has described both larva and pupa of *Tachina villica* (*Ann. Soc. Ent. Fr.*, 1861, p. 231, pl. 7); but as these descriptions are not readily accessible to the American reader, I reproduce from the Trans. St. Louis Ac. Sc., vol. iii, p. 238 1-9 my description of the larva and pupa of *Sarcophaga sarraceniæ*, and add for comparison that of *Belvoisia bifasciata* (Fab.), one of our largest and most beautiful species, parasitic or *Citheronia regalis* and various species of *Dryocampa*.

Sarcophaga sarraceniæ.—*Larva*—0.30–0.85 inch long. Body composed of but 11 visible joints exclusive of the head; microscopically and transversely shagreened; transversely wrinkled, the hind wrinkle on each joint more particularly prominent laterally. Head extremely small, or ¼ as large as joint 1, showing a division into two maxillary lobes at the tip and a larger labial lobe beneath, with a small bunch of setous fibres issuing from it; the black retractile jaws, of the ordinary form, issuing between these lobes, and the antennæ showing in two small rufous projections above the maxillary lobes; sparsely armed anteriorly with minute conical, sharp-pointed spines, decurved in front, directed backward beneath. Prothoracic spiracle pale rufous, retractile, sponge-like, studded with numerous lobules, divided at the end into a variable number of branches (6 being usually apparent, never more than 8), which in their turn ramify into lobules. Anal stigmatic cavity quite deep; the fleshy prominences on the carina surrounding it, sub-obsolete; the stigmata but slightly excavated below, the border brown, inclosing three brown openings, the lower ends of which reach to a circular clear space in the corneous and pale rufous peritreme. Anal prolegs quite small, with the longitudinal anal slit between, and a corneous plate in front of them.

Puparium—0.25–0.50 inch long; neither smooth nor highly polished, and varying from yellowish-brown to deep brown-black in color. Insections more or less distinctly traceable. Head and prothoracic joint retracted; the prothoracic spiracles protruding and forming two small ears about as long as joint 2; the mass of lobules hardened and rufous. Joints 2 and 3 constricted and flattened; 4 suddenly bulging. End of body squarely docked by spiracular cavity, the rim of which forms quite a ridge.

BELVOISIA BIFASCIATA.—*Larva*—Length 15mm. White, the skin soft; body cylindrical, tapering on the anterior joints towards the head, the apex obliquely truncated. Head small, furnished with two stout black hooks, situated under two crescentic elevations at a moderate distance apart; when viewed from in front the head obscurely bilobed, near the center of each lobe two chitinous points, one situated above the other. No prothoracic spiracles apparent, a distinct circular spiracle on the posterior border of the fourth joint behind the head, and situated slightly above the median line. The anterior border of each joint slightly prominent and, except on the dorsal side of the apical joints, roughened with minute points, the posterior border of the apical joints similarly roughened. Joints 4–11 with a distinct transverse median depression on the ventral side, the depression deepest on the intermediate joints, the portion behind this depression on the joint 11 forming a prominent transverse tubercle beneath the truncation, upon which the anal spiracles are situated. Anal spiracles black, each with the slit-like openings, and a circular spot in a clear space beneath them.

In Westwood's Introduction, vol. ii, fig. 131, 20 is copied from Bouché, a figure of the larva of *Tachina concinnata* of similar form to that of *Belvoisia;* but the peculiar "prothoracic spiracle" figured in connection is not apparent in the larva before me. In the normal form of the Tachinid *puparium* the anterior pair of spiracular openings are even with the general surface of the puparium, so as to be discoverable with difficulty. The true spiracles are internal, and may be found opposite these perforations on the membrane which lines the puparium after the fly has escaped. The puparium is reddish-brown, the anal spiracles and the anus black; the joint of the body not distinct; the anal spiracles distinctly upon the surface of the subtruncated posterior end, not situated in a cavity as in *Sarcophaga;* just beneath these spiracles is a slight transverse elevation.

The puparium of *Belvoisia bifasciata* differs somewhat from the ordinary form. It is black, roughened, increases in width posteriorly, has the anal spiracles drawn far forward upon the back, and each represented by three swollen tubercles, and the space between them and the tip of the puparium is very irregular and has a conspicuous transverse depression.

Issuing from the Chrysalis.—The foregoing species issue in the larva or maggot state mostly from the worm and undergo their transformations independently of their host. All the other parasites yet to be mentioned undergo their transformations within the chrysalis and gnaw their way out of the more or less completely emptied shell as perfect insects. The Aletia is attacked, however, in the larva state, the parent parasite stinging and laying her eggs beneath the skin of the worm, and the parasitic larvæ affecting the vital parts only after the transformation of the victim to the chrysalis state. Whether or not any of the species here mentioned are secondary parasites will be considered in the final report; at present there is reason to believe that they are all primary.

THE DEVOURING CIRROSPILUS.—The chrysalides of Aletia formed during the latter part of the season are frequently infested with this little parasite, each chrysalis nourishing a number, which eat their way through the shell in the form of small black flies. This parasite is generally distributed, having been found by myself and Professor Willet in Georgia, and by Mr. Schwarz in Texas. The larvæ are pale elongate, egg-like maggots, and the flies issue all through the autumn, during mild winter weather and (the later ones) in spring. It belongs to the family *Chalcididæ*, the insects of which are distinguished by their

parasitic habits, small size, metallic colors, veinless wings, thickened hind thighs, and by the pupa being formed without a cocoon.

2. Cirrospilus esurus Riley (Can. Ent., vol. xi, p. 162).—Length 1.5mm. Dull black; knees, tibiæ, and tarsi yellowish; the posterior tibiæ sometimes dusky. Eyes with scattered short bristles. Antennæ of the ♂ 9-jointed, with the joints of the flagellum subequal and beset with bristles, the ninth joint small. Antennæ of the ♀ 8-jointed, the fourth and fifth shorter than the second and third, the three apical joints forming a club. Thorax above microscopically punctate; parapsides distinct and elevated; scutellum with a longitudinal impressed line on each side. Wings hyaline, pubescent, but the cilia short; base of ulna uneven; radius not developed. Abdomen short and sessile; ovate.

This species shows relationship with the genus *Tetrastichus* Haliday, and may ultimately be referred there. For the present I prefer to place it in the older genus.

The Ovate Chalcis—A second species belonging to the same family as the preceding has similar habits, but being much larger issues in fewer numbers, and as a general thing singly, from the chrysalis. It is a black fly (*Chalcis ovata* Say,) with the greatly swollen hind thighs characteristic of the genus, and by means of which these insects are able to jump with great vigor. The species may be easily recognized by the posterior thighs being black with a yellow spot at the tip and by the tegulæ being entirely yellow. From the allied genus *Smicra*, with which *Chalcis* agrees in the swollen hind thighs, it may be distinguished by the sessile abdomen.

The *larva* is a slender legless maggot 7mm. in length. The body tapers at each end, particularly behind, and has a conspicuous lateral ridge. The head is similar to that of the *Pimpla* larva described further on, but the mandibles are nearly concealed, being covered by the other mouth parts. The first three joints of the body are separated by deeper constrictions than the succeeding joints, and the lateral tubercles on joints 4–10 have a smaller but distinct tubercle behind them. The spiracles in the alcoholic specimen are indistinct, owing to their agreeing with the skin in color; but their position is apparent upon the anterior border of the second, third, fourth, and several of the posterior joints. Length, 7mm.

The *pupa* is short and robust; pale at first but becoming brown, the head and thorax anteriorly darker. It has two prominent tubercles between the eyes just above the insertion of the antennæ, and above each of these a slight ridge extending as high as the lower ocellus, which is situated on a slight prominence within the fork of an impressed line on the vertex. Only five distinct joints in the antennæ between the scape and the club. Posterior femora larger than the wing-pads and slightly overlapped by them, posterior tarsi not extending to the tip of the abdomen. Tip of the abdomen narrowed and ending in a small truncated square.

The species is widespread in the United States and occurs also in Mexico and the West Indies. I have reared it from Aletia chrysalides collected by Professor Willet in Georgia, Professor Comstock in Alabama, Mr. Schwarz in Texas, Dr. Anderson in Mississippi, and myself in the first-mentioned State and in North Carolina; while I have likewise reared it from *Desmia maculalis* (the Grape leaf-folder), in Missouri, and found it commonly infesting the chrysalides of certain Hackberry-feeding worms (*Apatura Lycaon*, Fabr., and *A. Herse*, F.) in several of the Southern States.

Still a third of these smaller Hymenopterous parasites issuing in numbers from the Aletia chrysalis was obtained the past summer, and referred to me for determination by Professor Comstock. It belongs to an allied family (*Proctotrupidæ*), in which, as compared with the *Chalcididæ*, the body is generally longer, the antennæ also longer, the colors more sober, the wings have a few veins, the hind thighs are not fitted for jumping, and the pupa is usually formed in a cocoon. The species under consideration approaches the genus *Basalys* of Westwood, and I append a description of it:

DIDICTYUM* nov. gen.—*Head* transverse; three ocelli, approximate and triangularly arranged; labial palpi 3-jointed; antennæ inserted in front and close together: in the ♀ hardly reaching to the abdomen, 13-jointed, the two basal joints stout; joints 3–7 suddenly narrowed and together not much longer than 1 and 2; 3 being twice as long as the others; 8–13 twice as stout, peduncled, subequal in length, very slightly narrowing toward tip: in the ♂ as long as body, 15-jointed, joint 3 twice as long as any of the others, 4–15 subequal in length. *Thorax* as long as abdomen, slightly wider in the middle than the head; scutellum prominently raised, subovate and marginally ridged; legs with the tarsi uniformly 5-jointed; front wings without stigma, but with the veins forming with the costa two closed cells; hind wings with a stout costal vein, reaching and broadening to basal third of wing, where it is suddenly bent upward. *Abdomen* narrower than thorax, with a short peduncle.

D. zigzag, n. sp.—Average length 1.6mm. Body uniformly polished black. Legs, palpi, and antennæ reddish in female; coxæ, femora, and antennæ toward tip infuscate in the male. Peduncled joints of antennæ with a few minute spines around the crown and longitudinally striate. Base of thorax and of abdomen with pale pubescent hairs. Wings hyaline, sparsely beset with minute spines which increase radially and form a fringe around the posterior half; the veins of front wings forming a sprawling W with partial cross veins proceeding from the lower angles, the basal cross vein longest; the longitudinal veins with a few prominent spines. Abdomen, ♀, showing but 4 joints, the terminal three short and hardly distinguishable ventrally.

The genus is readily distinguished, by the character of the venation and the structure of the antennæ, from *Basalys* Westwood, with which it has some affinity.

We next have certain larger, true Ichneumon-flies (*Ichneumonidæ*), of which but one specimen succeeds in maturing and issuing from the Aletia chrysalis, though more sometimes hatch within the worm, the others being eventually destroyed by the more successful rival.

THE WATCHFUL PIMPLA.—This species (*Pimpla conquisitor*, Say†), sometimes destroys from fifteen to twenty per cent. of the last brood of Aletia, and the chrysalides that are whole and that appear sound or alive after a good frost are found to contain its larva or pupa in still greater proportion. It has been obtained from Aletia from all parts of the South, and by most of the observers and agents of the Commission, the fly issuing sometimes in the Fall, but mostly in spring. It is a black, four-winged fly, varying in length from one-fourth to one-half of an inch, and may be

* Δίς double; δίκτυον, net.

† *Cryptus conquisitor*, Say, Bost. Jour., i. 232, of which, as Walsh, (Canadian Entomologist, ii, 12,) pointed out, *Cryptus plcurivinctus*, Say, l. c., 235, is a synonym. By some oversight *plcurivinctus* stands as a synonym under *annulicornis*, Cress., instead of *conquisitor* in Mr. Cresson's List of the North American *Pimplariæ*, (Trans. Am. Ent. Soc., iii, 170.)

distinguished from other native species of the genus *Pimpla* by having the margins of the abdominal segments white. The exserted ovipositor does not exceed one-half the length of the abdomen, and the male may be recognized by the absence of an ovipositor and by his more slender body. Say reared the species from a follicle of a case-bearing Bombycid moth with transparent wings, probably the common Bag Worm (*Thyridopteryx ephemeræformis*, Haw.*).

The *larva* of *Pimpla conquisitor* is a legless maggot of a whitish color, the head well defined, concolorous with the body and with distinct mouth parts; the tips of the mandibles black. The body tapers posteriorly, the skin is finely wrinkled and no spiracles are apparent; the first three joints have a longitudinal, impressed line low down on the sides, and the succeeding joints have a similar line higher up, and above it a distinct lateral ridge or series of protuberances. The mandibles are slender and pointed, situated beneath the labrum and above the three fleshy tubercles which represent the maxillæ and labrum. Above the labrum are two distant and very indistinct circles with a minute point in the center, indicating the position of the antennæ. The largest larva examined measured 9mm.

The *pupa* resembles the imago in the form of body, but the colors are undeveloped, the wings unexpanded, and the legs, antennæ, and palpi laid along the sides and breast. In the ♂ the tip of the abdomen is abruptly terminated and just before the tip on each side is a tubercle bearing two projecting teeth; in the ♀ the ovipositor is curved up over the back.

The species is widely distributed over the United States and attacks a large number of other Lepidopterous larvæ. It is probably the most effectual as it is the most noticeable check to Aletia, and that it has always attacked it seems most probable; for the following account by Dr. Gorham, published in 1852 in the article in De Bow's Industrial Resources, etc. (p. 168), already cited, gives such an exact account of it and such a full general description, that, while he could not name it, there is no question as to its identity with the species under consideration. In endeavoring to explain the disappearance of the Cotton Worm in early winter, Dr. Gorham writes:†

* * * Let us take a pocketful of these [the chrysalides] home and place them beneath tumblers, and wait patiently to see what they will produce. * * * About the fifteenth of November the insect appeared, but, *mirabile dictu!* as different from the Cotton fly as it is possible to suppose one insect could differ from another. It belonged altogether to a different family, a description of which I give as follows:

Antennæ filiform; black, six lines in length. Palpi four, two external and two intermediate, the external white, twice the length of the other two, in shape angular, the angles projecting externally. The two middle are straight, scarcely perceptible over a strong light; they are of a dark color. Wings four; hymenopterous; incumbent, extending to and exactly even with the end of the tail; shape of the wings, which are small and extremely delicate, like that of a fan. Front legs half the length of the posterior, of a uniform orange color; the intermediate legs very little longer than the anterior; the thighs of a deep orange color, the rest of the leg annulated with

* In the Trans. St. Louis Acad. Sci., iii, 137, a detailed description of *conquisitor* is given by Mr. Walsh, who there identified Say's *Bombyx* with *Clisiocampa americana*; but this determination is not in accord with Say's account of the moth.

† Dr. Phares refers to Dr. Gorham's experience with this parasite in his excellent article published in the *Rural Carolinian* for August, 1870 (vol. i, p. 689), but only in order to criticise some of Dr. Gorham's deductions, and not to confirm its occurrence by his own experience.

orange and white. The posterior legs long in comparison to the others; thighs of a deep orange color, the rest of the leg annulated with black and white, the rings being larger than those of the intermediate. The trunk is of a uniform shining black, as would be the upper surface of the abdomen also were it not for the very narrow white bands which connect the black scales together, giving to the abdomen an annulated appearance; these white lines do not encircle the abdomen, but terminate uniformly on the sides. On the under surface of the abdomen these white rings again commence, which are larger than those on the upper surface, causing the abdomen to look almost white. The tail terminates in a bifurcated sheath, inclosing a long blunt sting, projecting considerably beyond the tail, and forming a very prominent feature in the general figure of the insect. This is a small, slender insect, much longer than the honey bee, but not so thick.

Three years later what is evidently the same species is referred to again without name by Mr. Glover, who says:* "Some chrysalides of the cotton caterpillar, which had been preserved during the summer of 1855, as an experiment to try whether they would live until the following spring, having been hatched prematurely by the heat of the room in which they were kept, two Ichneumon-flies were produced of a slender shape, and about half an inch in length; the abdomen or body of the female was black, and marked with seven light-colored, yellowish narrow rings around it," etc. In the Agricultural Report for 1867 (p. 61) his remarks that the cotton caterpillar is destroyed by a "small yellow and black banded ichneumon-fly" probably refer to the same species.

FIG. 27.—PIMPLA ANNULIPES: outline side view of female and of male abdomen. (After Riley.)

THE RING-LEGGED PIMPLA.—This is another species (*Pimpla annulipes* Br., Fig. 27) of the same genus, having about the same size and general appearance, but having the rings on the abdomen dusky or reddish instead of whitish, and differing in other minute particulars. It is less numerous than the preceding, but I have obtained it from chrysalides sent by Dr. Anderson, and received it the past summer from Professor Comstock as reared from Aletia. In habit it is precisely like *conquisitor*, and equally widespread and destructive to other species of Lepidoptera,† being one of the few parasites of the common Apple Worm (*Carpocapsa pomonella*).

CRYPTUS NUNCIUS.—A third Ichneumon-fly belonging to a different genus and having similar habits with the Pimplas just described, except that the pupa is formed in a cocoon, may (considering the known variability of coloration in the species of the genus) be referred to *Cryptus nuncius*, Say. It is a black and red, four-winged fly with transparent wings, and issues from the Aletia chrysalis during the spring. It is a well-known parasite of our large native silkworms, *Attacus promethea*,

*Patent Office Report 1855 (Agriculture), p. 111.

†See Mo. Ent. Repts., iv, p. 43; v, p. 49.

A. cecropia, and *A. polyphemus*, from the cocoons of which it emerges in the Northern States early in the spring, a considerable number of the parasite appearing from a single cocoon.

A female specimen from Aletia has the head and thorax black, the 8th–10th joints of the antennæ white, the palpi black, the legs including all the coxæ red, with the tips of the posterior femora and of the posterior tibiæ black, and the posterior tarsi tinged with brown. The first four joints of the abdomen are entirely red, the succeeding joints and the sheaths of the ovipositor black, the ovipositor itself reddish; the apical joints of the abdomen have a white spot above. Relying upon the length of the ovipositor as a character for separating *nuncius*, Say, from *samiæ*, Pack.,* the female of the present species may be distinguished by the ovipositor being much shorter than the abdomen, as shown in Fig. 28, *b;* Fig. 28, *a* representing *Cryptus samiæ*. Fig. 28, *c* indicates the form of the abdomen in the male.

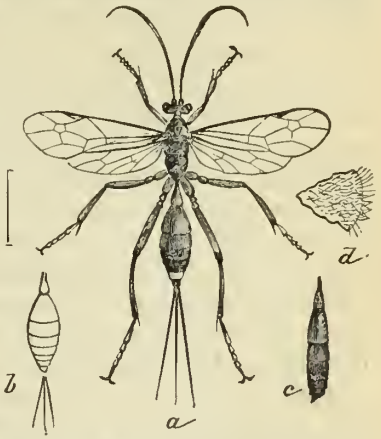


Fig. 28.—Cryptus nuncius: *a*, female; *b*, female abdomen of *C. samiæ*; *c*, male abdomen; *d*, highly magnified piece of wing—hair-line showing natural length. (After Riley.)

We thus have ten distinct parasites actually observed to infest Aletia, and issuing either from the egg (1 species), from the larvæ (3 species), or from the chrysalis (6 species), and belonging to two orders and four families. A yet unbred species (doubtless subf. *Braconides*) that destroys the young worm, its larvæ issuing from the back of their victim and there forming loose cocoons in company was sent me from Alabama by Professor Comstock; while Mr. Glover has figured, in the Patent Office report for 1855, just cited (Pl. X, Fig. 4), what is evidently a parasite belonging to the true genus *Ichneumon*, which he found in cotton fields near Columbus, Ga., "busily employed in search of some caterpillars."

Aletia may truly be said, therefore, to have its full share of parasitic checks, and the number will, without much doubt, be increased by future observation.

12. REMEDIES: MEANS OF COPING WITH THE INSECT.

For the present purpose these may be considered under the several heads of [1] Prevention; [2] Mechanical Means of Killing the Worms; [3] Poisoning the Worms; and [4] Destruction of the Moth.

In treating of the various machines, contrivances, and compounds that have been used for the destruction of this insect, it is my endeavor to bring to the notice of the planter all those that are worthy of mention; to point out their advantages and disadvantages; wherein they are susceptible of improvement; and how they may be used most economically

* The name *Cryptus extrematis*, Cress. should yield to *C. samiæ*, Pack., because of two species (one of which is *nuncius*) were combined under it in the original description.

and effectively. The planter can then judge for himself which he can most profitably adopt, according as his own circumstances dictate. In doing this, some of the earlier machines and contrivances, though now superseded by improved ones, will be enumerated, because they are of interest from an historical point of view, as showing what has been done by the inventive genius of the South in contending, and by no means unsuccessfully, against this pest.

From the variety of the inventions and the ingenuity displayed in many of them, it will be seen that, in this instance, the energy and enterprise of the southern planter compare favorably with that shown by cultivators of the soil in other sections of the country in contending with other destructive insects.

A survey of the whole subject brings out prominently two important facts that should be emphasized.

First. Though, as we have already seen (p. 8), there is every reason to believe that the ravages of the worm were proportionally as great before as they have been since the late war, yet all the more important inventions post-date that period. Prior thereto only the more primitive and ineffective means of destruction, such as hand-picking and the use of fires and lights in the fields at night, were resorted to.

Secondly, by far the greater number of the machines have been invented in Texas, a fact which corroborates previous statements that the worm occurs more regularly and more disastrously there than in other States. Both facts are indicative of the more healthy development of the South under free as compared with slave labor.

PREVENTION.

That much can be done toward preventing the ravages of this worm there is no question. The mode of cultivation has some influence; the principal object should be to hasten maturity so that a portion of the crop shall be beyond the reach of harm from the more disastrous July and August broods. Aside from careful and frequent cultivation, which, moreover, has a tendency to disturb and knock off the worms, early planting in this connection is to be urged, though of course it has its drawback in exceptional seasons in the risk of late frosts. The use of early maturing varieties and of cotton seed obtained from more northern regions will also help to defeat the enemy, while it has long been known that some varieties are less subject to attack than others—the long-staple being much more injured, for instance, than short-staple when planted side by side. Topping the cotton, while it would have very little effect in the early part of the season, may be employed to good advantage later, in cases where desperate means and the loss of the top crop are warranted. The frequent exemption of small fields that are separated from larger ones or surrounded by some other crop is noticeable and suggestive in this connection, while it will always be well to avoid planting

cotton in those spots where the worms have been known to first reappear year after year. Diversified agriculture, and the rotation of crops on the same field are most desirable in this connection.

The protection of those natural enemies of the worm that permit of it should not be neglected, and all shooting and trapping of the smaller birds prohibited, while the killing of hawks and other birds of prey should be encouraged. Tame fowls, such as chickens, turkeys, and Guinea-hens will prove valuable, especially if brought up near those spots where the first worms occur. The leaving of an occasional tree in fields in an open country, or even old stumps, while it may be looked upon by some as thriftless agriculture, is nevertheless advisable, for the immunity of fields containing such is often noticeable. Some attribute this immunity to the shade afforded by the trees, but the real explanation is more probably to be found in the protection they offer to birds and ants. These last, more particularly, are less liable to be washed away and destroyed by heavy rains at points where trees and stumps occur. The importance of the destruction of the first moths, whether by lights or poisons, will be shown farther on, while that of the killing of the first worms is too apparent to need enforcing. The fact that vast numbers of late chrysalides are carried into the gin house, and that the moths issuing therefrom are so likely to find the requisite winter protection there, points to the expediency of removing and destroying those chrysalides as soon as possible and not allowing them to remain in the gin house until they hatch.

Dr. Phares has suggested that by systematically deferring the planting of cotton till the end of May, or until all the hibernating moths had perished without finding food for their issue, and then planting some early maturing variety, we might entirely prevent the injuries of the worm. This would be an excellent suggestion could the planter know beforehand that it would be necessary, and were there not decided advantages, as just set forth, in getting early maturity.

I will not discuss here the effects of interspersing or surrounding the cotton with corn, as is so often practiced in the South; for while it may have some effect in lessening the Cotton Worm, there is not yet sufficient confirmation of the fact, and the custom doubtless helps to increase the injury from the Boll Worm.

Finally jute (*Corchorus capsularis*) sown around a cotton field or in spaces between the rows has been strongly recommended by Mr. J. Curtis Waldo, of New Orleans, as a preventive, the recommendation being ostensibly based on observation. None of the correspondents of the Commission have given any corroborative experience in answer to the direct question on this subject contained in our circular. Its effects I hope to test another season.

MECHANICAL MEANS OF KILLING THE WORMS.

During very hot, clear weather, much good may be accomplished by knocking down or brushing the worms from the plants on to the ground

and crushing or killing them in various ways. One of the best methods of doing this is, in the words of Dr. J. D. Hoyt, of Livingston, Ala.,* "to drag something like a piece of cotton bagging along over the rows of cotton, forward and back; which may be long enough to extend across several rows, and having short lines attached to one edge, a little further apart than the width of the rows, and a hand at each line, and all abreast pass along between the rows, and then back; when the brushing and shaking of the stalks by the bagging will clear the cotton mostly of the worms. In this way, a set of hands can go over their crop in a day or two; when they should return to the beginning and go over again; and continue so doing as long as any number of worms are found on the stalks."

A number of machines have been invented to expedite these mechanical means of destroying the Colorado potato-beetle and other leaf-feeding insects, and a few of similar character have been especially contrived for the Cotton Worm. They will hardly come into general use for the simple reason that, under ordinary circumstances, they are more expensive and less satisfactory than the methods of poisoning. But as many persons are opposed to the use of poisons and prefer to resort to other modes of destruction, even when more expensive, we shall give an account of the more useful ones.

Machine for brushing off the Worms.

THE EWING BRUSHING-MACHINE.—One of the earliest-used machines of this kind is that invented by Mr. William Ewing, of Columbia, La., in 1869. Starting from the observation that the worms drop or throw themselves from the plant upon moderate disturbance of the leaves and branches, Mr. Ewing constructed a very simple machine, of which Fig. 29 represents a top view and Fig. 30 a side view. In these drawings *a* represents a frame constructed of wood or other suitable material, *e d e* the wheels, and *f* a yoke or drawing device. Upon the front wheel *e*, on either side, are pins *g* which act upon the lower ends *h* of the arms *i* as the wheel is rotated. These arms are pivoted to plates *j*, and extend upward and outward so as to pass along the sides and over the top of the plants. To the upper part of these arms other tubular arms *k* are affixed, so that the

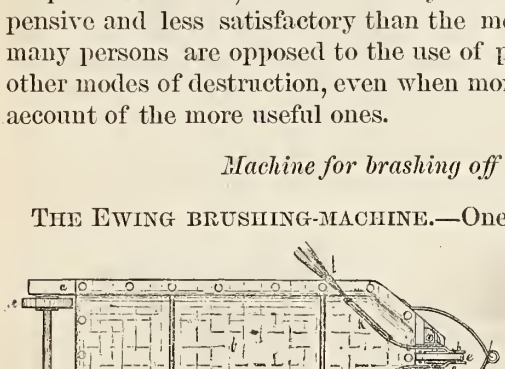


FIG. 29.—EWING BRUSHING-MACHINE: Top view.

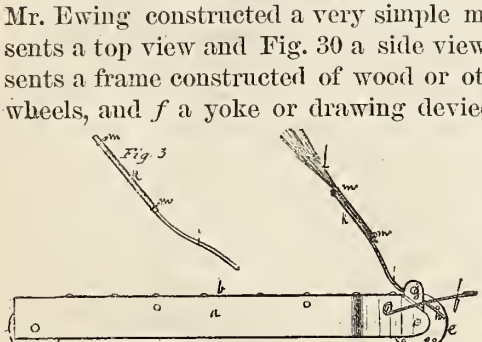


FIG. 30.—EWING BRUSHING-MACHINE: Side view.

*Prize Essay, Selma, 1874.

brushes *l*, secured thereto and held in place by eyes or rings *m*, may be adjusted to the height of the plants. Between the frame a canvas, *b*, is stretched. This latter is smeared with tar or any other material to which the worms will stick or adhere for a reasonable length of time.

This machine is intended to be drawn by hand, or by a horse or mule, between two rows of plants, the leaves and branches of which are agitated by the arms and brushes. The worms fall upon the smeared surface of the canvas, and may easily be gathered up and destroyed. It is evident, however, that only those worms are caught which fall toward the inside of the rows of plants between which the machine passes. To obviate this drawback, Mr. Ewing suggests the attaching to each side of the frame another light frame of wire rods or cane, reaching above the tops of the plants, thence down again to near the ground, and there carrying a canvas which is likewise smeared with tar.

THE HELM BRUSHING-MACHINE.—Another machine for the same purpose was invented by Mr. J. Helm, of Hochheim, Tex., in 1873. It consists of a movable frame, drawn by animals over the fields, to straddle, with brushes made of split white oak or other suitable material, the leaves and branches of a row of cotton-plants, and to kill the dislodged worms on the ground by means of jointed bottom pieces or slides. In the accompanying outlines Fig. 31 represents a side elevation of this machine; Fig. 32 a vertical transverse section of the lower part of the same taken on the plane of the line *c c* of Fig. 31; and Fig. 33 is a vertical transverse section on the line *k k* of Fig. 31.

In the accompanying drawing, the letter A represents a frame composed of two bottom boards, *a a*, of four or more uprights, *b b*, and a suitable series of cross-braces, *d d*. The boards *a a* are on a level and parallel to each other, and have wings *e e* and *f f* hinged to their inner and outer edges, respectively. To each of the front parts *b* is pivoted, at *g*, a lever, B, which carries a wheel, C, at its front end. There are thus two such wheels C C that rest on the ground in front of the apparatus. Draft-hooks *h h* are applied to the front ends of the levers B for hitching the draft animals to, by which the machine is drawn over the field. The levers B can be swung on their pivots to raise the frame A on the wheels C whenever stones, stumps, or other obstructions are to be avoided. In such case the levers B are or can be locked to toothed plates *i*, which are applied to the rear posts *b*, as indicated in Fig. 31. When the machine is to be turned it is also necessary to

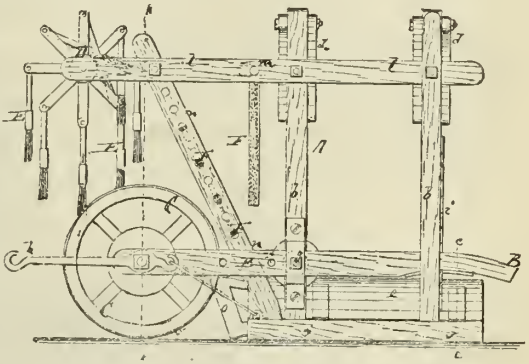


FIG. 31.—HELM BRUSHING-MACHINE: side view.

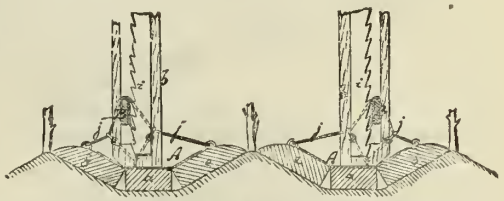


FIG. 32.—HELM BRUSHING-MACHINE: transverse section of lower part.

elevate the frame A off the ground, and throw the whole weight of the apparatus upon the wheels C. Whenever the frame A is thus raised the wings *e* and *f* will be swung up to clear the upper expanded parts of the cotton plants. This is done by connecting the two wings that are hinged to each board *a* with each other by a string, *j*, which passes over the lever B, so that in swinging up such lever the string will be drawn with it to contract or swing up the wing. In the front ends of two horizontal bars, *l l*, that are longitudinally secured to the upper parts of the posts *b*, is hung a transverse drum or shaft, D, from which a series of pointed brushes, E E, are suspended. Brushes F F are also rigidly affixed to a cross-bar, *m*, back of the shaft D, and to inclined bars *n n* that are secured to the sides of the frame A.

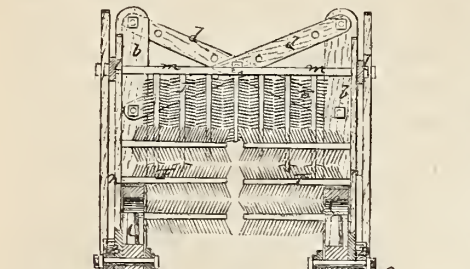


FIG. 33.—HELM BRUSHING-MACHINE: transverse section.

For use, the machine is placed to straddle a row of cotton between the inner wings *e e*. The boards *a a* rest in the furrows and the outer wings on the rising sides of the adjoining ridges, all as clearly shown in Fig. 2. The wings rest with their weight on the sides of the ridges. The machine being drawn ahead, the shaft D is revolved by its brushes E, which come in contact with the cotton plants. Also, by subsequent contact with the brushes F F, the worms are all swept to the ground, on which they are finally crushed and destroyed by the weight of the boards *a* and wings *e f*.

Apart from the circumstance that this machine straddles only one row of plants, it is extremely doubtful whether all, or even a large portion of the worms would be crushed by the bottom pieces, considering the uneven nature of the ground.

Two other machines, though originally intended for clearing potato-vines of their insect enemies, deserve notice here.

THE WOOD-SMITH BRUSHING-MACHINE.—The first of these was invented by Messrs. G. W. Wood and Charles H. Smith, of Faribault, Minn., in April, 1879, and consists of an apparatus mounted on wheels which is drawn between the rows of plants, and by suitably-shaped wings gathers the plants into a bunch and shakes them, thereby shaking off the larvæ into a receptacle, from which they cannot escape. The parts of the apparatus are adjustable to suit the height of the plants.

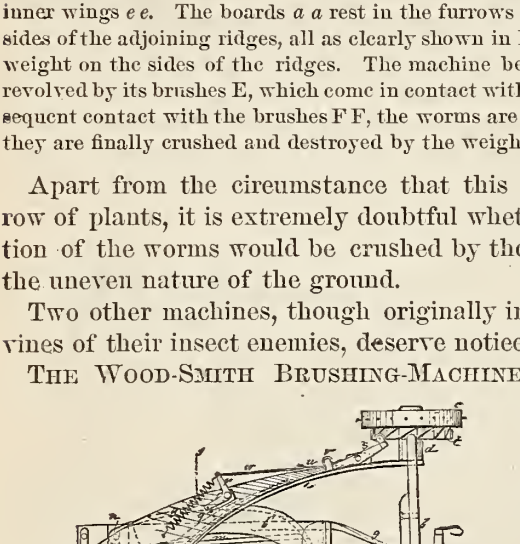


Fig. 34.—WOOD-SMITH BRUSHING-MACHINE: from above.

In the accompanying drawings, Fig. 34 is a plan of the apparatus.

Fig. 35 is a longitudinal section at the line *x x*. Fig. 36 is a cross-section at the line *y y*.

Similar letters of reference indicate corresponding parts. *a a* are vertical standards, connected together by a cross-bar, *b*, at their upper ends. *c c* are wheels mounted on short axles fitted in the boxes *d*, at the lower ends of standards *a*.

The standards *a* are at such a distance apart that the wheels *c* will run between the rows of plants and two rows of plants be between the wheels.

The cross-bar *b* is made in two pieces, as shown, connected together by screws, so that the bar can be adjusted according to the width of the rows. *e e* are wings, one at each side of the apparatus. The forward ends of the wings are attached to the standards *a*, and their rear ends are connected together at the center line of the machine. These wings *e* are of suitable width, and they are attached with their edges vertical at the forward end, and are twisted so as to lie flat where they are connected together at the rear end. *f* is a pan-shaped receptacle, attached by arms *g* to a bar, *h*, that is suspended from bar *b*, midway between the wheels *c*. *i* is a vertical rod rising from the rear end of the receptacle *f*, and passing through a hole in the ends of wings *e*.

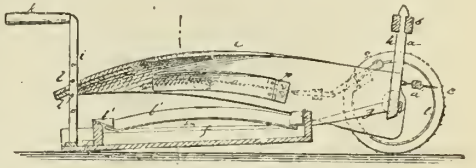


Fig. 35.—Wood-Smith Brushing-Machine: longitudinal section.

The upper end of rod *i* is provided with a handle, *k*, by which the rear end of the machine may be managed. There are holes in rod *i* into which pins *l l* may be inserted to retain the rear ends of the wings *e* at the desired height, according to the growth of the plants. The strips *m* that form the sides of the receptacle *f* are pivoted by pins *n* at one end, so that the receptacle can be made wider or the reverse, according to the width of the rows.

At the inner side of the wings *e*, and projecting over the receptacle, are flappers *o o*, hinged at *p*. Each of these flappers has a rod, *q*, passing through the wing that the flapper is hinged to, and connected with a crank-lever, *r*, hung at the outside of the wing. *s* is a lever fulcrumed at the forward end of the wing in such position that one end of the lever is acted upon by the teeth *t* attached to the inner side of the wheel *c*. The other end of the lever is connected by a strap, *u*, that passes beneath a roller, *v*, to a rod, *w*, that is attached to crank-lever *x*; *y* is a spring connected to lever *u* and to the wing *c*. The teeth *t* depress the lever *s* and draw upon the crank-lever *r* and spring *y* and draw the flapper outward; but as soon as the lever *s* clears the tooth the flapper springs out quickly. The arrangement is the same on both flappers *o*, and by that means a series of rapid blows are given upon plants gathered by the wings.

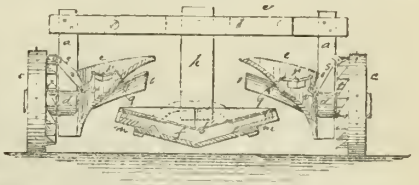


Fig. 36.—Wood-Smith Machine: cross-section.

A horse is to be attached to the whiffletree *a'*, that is hung on bar *h*. The horse will walk between the rows of plants that are to be operated upon by the apparatus, and the receptacle *f* will run on the ground between the rows. As the apparatus is drawn forward the plants pass beneath the bar *b*, one row at each side of the bar *h* and pan *f*, and the rows will be gathered together and bent down beneath the wings. The flappers will shake the plant and the larvæ will be rubbed and shaken off into the receptacle.

The Iske Brushing-Machine.—This was invented by Mr. Anthony Iske, of Lancaster, Pa., in 1876.

It consists of an upright frame, open beneath, with two wheels in

front, and is drawn over one row of plants at a time. A row of brushes, made of broom-corn or of any other suitable material, is fastened to a longitudinal beam, which is adjustable to the height of the plants and agitated by a contrivance similar to that in Mr. Ewing's machine. The worms dislodged by the action of these brushes fall in two canoe-shaped trays, which are supported by swinging arms, and slide along one on each side of the row of plants close to their base. On the outer side of each, these trays are provided with a smooth inclining shelf, which dips into the tray, and with a vertical backboard in order to prevent any worms from being beaten beyond these trays. In using this machine it is necessary to smear the trays with tar or coal-oil.

Finally, having proved that the least touch of kerosene is as fatal to the Cotton Worm as it is to so many other insects, I have no hesitation in recommending as a cheap substitute for these brushing-machines, where youthful labor is abundant, the use of sheet-iron pans, over the bottom of which kerosene or coal-tar is spread. They proved very successful in 1877, when the Western farmers were contending with young locusts; and, drawn between the rows of cotton, while the worms are being brushed off in the manner recommended by Mr. Hoyt, they would prove equally satisfactory when the weather is not sufficiently hot and dry to insure the death of the worms otherwise. Or a still simpler arrangement might be adopted, viz: a cloth stretched on a frame that will draw between the rows and kept saturated with kerosene.

POISONING THE WORMS.

With the introduction of mineral poisons for the destruction of the worms a new impetus was given to the invention of machines and contrivances for the application of these poisons either as powder or in water. The large number of such inventions made during the past six years, and the activity still displayed in adding improvements, furnish evidence that this poisoning of the worms has so far proved most satisfactory in protecting the crop. The fact is that a judicious and timely application of the best poison will always, even under unfavorable conditions and in bad "worm years," enable the energetic planter to save at least the larger portion of his crop. There is no question but that concerted action in the application of poisons early in the season, in those counties in which the worms first appear, would not only effectually protect the crop in those counties at comparatively little cost and labor, but also prevent, or at any rate retard, the spread and migration of the moths into the rest of the cotton belt. There is little hope, however, of any such concert of action in the larger part of the cotton-growing country to-day, because where there is one planter who superintends the cultivation of his own land and is alive to the importance of such work, there are many cotton farms either rented or owned by freedmen who are usually ignorant and shiftless and with whom intelligent co-operation is almost, if not quite, impossible. Each planter must, therefore,

depend on his own efforts, and it is a satisfaction to know that these may be successful notwithstanding more careless neighbors.

There are certain general principles which I would here insist on that should govern the use of these poisons. It is very evident from the habits of the worms, as already detailed, that such poisons will prove most satisfactory if applied to the under side of the leaves when the worms first begin to appear in numbers. While poisons in solution can be applied at any time of the day during dry weather, those in powder are most advantageously applied in the early morning hours while yet the plants are moist with dew. The greater adhesiveness given to the poison the better. Those used in powder form are naturally the most effectual in rainy weather, during which, as we have seen, the worms are most injurious. These dry poisons have, further, the advantage for the small planter that they can be used with less extensive and expensive apparatus and with less labor than those in solution. Finally, too much stress cannot be laid on the importance of having the materials ready prepared in advance, or on their use as soon as the eggs or young worms are noticed. It is too often the habit to wait until the plants begin to be "ragged" before attempting to poison. The operation is always more costly and unsatisfactory at this period, and there is danger that, with the most strenuous efforts, irreparable damage will be done before all the cotton is gone over. It often happens also, since the same influences cause the multiplication of the worms over pretty large areas, that a sudden and general demand for the poisons by those who have not previously laid in a stock increases the price or exhausts the market, so that many are left without hope of saving their crop.

Arsenical Compounds.

Arsenical compounds have the acknowledged disadvantage of being dangerous to man and beast. Some writers, taking a most narrow and theoretical view of the subject, bitterly object to their use on the score of their dangerous character, exaggerating in their enthusiasm the injury that has resulted from their use. Not only hundreds of tons but thousands of tons of these mineral poisons have been employed during the past decade by farmers throughout the country, whether to protect the potato crop or the cotton crop or other products of the soil from the ruinous attacks of insects. The general experience during this long period and over the whole country is so emphatically in favor of their use and their perfect safety and harmlessness, with ordinary precautions, as to render almost laughable the objections of the few persons referred to. No advancement, no improvement, no general benefit to the human race is ever accomplished without some attendant danger, and those who inveigh against such improvements as increasing the risks to life stand on the same footing as the opponents to arsenical poisons as insecticides. It is a noteworthy fact that, since I have been pursuing this Cotton-insect investigation, not a single fatal case of human poisoning by the use of these minerals against the worm has come to my notice

from the South, notwithstanding they are often used in that section of the country with great recklessness. Nevertheless it is no uncommon thing to hear of partial poisoning among negroes, resulting from that indifference which comes from constant use, and the importance of care and caution cannot be too strongly urged, especially near towns or in thickly settled neighborhoods.* Most of these poisons can be applied to the leaves either in water or dry, but some of the compounds are prepared so as to be used only in the former manner.

It has been my principal ambition to discover some substitute for these poisons that shall be equally effectual, harmless to man, and cheaper. The experiments that have been carried on by the Commission with this object have been sufficiently encouraging, as the sequence will show; yet, for the reasons stated in the Introduction, they are by no means exhaustive, and there is every reason to hope for great improvement in this direction.

PARIS GREEN.—The nature and effects of this poison are now too well and generally known among planters to need consideration. Planters have too often found in its use a path leading from threatened ruin and bankruptcy to be much influenced by theoretical arguments against it. A study of its effects, based upon experience and experiment, whether upon the plant or upon the soil, shows that no harm results from its judicious use.† My expectations in first suggesting its use as a Cotton-Worm destroyer at the Saint Louis meeting of the National Agricultural Congress in 1872, and more confidently recommending it before the same body at Indianapolis in 1873, have been fully realized by the experience of the past seven years. Complaints of its ineffieacy are readily traceable either to faulty application or the use of an adulterated article. Its principal disadvantages are its great cost, often increased by the exhorbitant profits demanded by merchants, and the consequent temptation to adulterate or imitate the genuine article.‡ Another disadvantage is the difficulty of keeping it suspended in water, but this is easily overcome either by the employment of an additional hand to keep the water stirred up, or by adding to the various pumps with which the poison is distributed a simple self-acting lever inside of the barrel or other vessel containing it. This, together with the motion of the pump, is sufficient to prevent settlement. Its advantage over the other arsenical poisons, besides its undoubted efficacy, is that it is least liable to scald the leaves and to cause the young bolls to shed.

If used in liquid suspension, a simple mixing with water is sufficient in dry weather. If pure, one-half pound to 40 gallons will answer. One

* So long as such cases of poisoning are liable to occur it will be well to widely publish the means of counteracting the poison. The antidote most highly recommended and found in practice to be effectual is hydrated sesquioxide or peroxide of iron, which may be purchased at any drug store. A few spoonfuls taken soon after a case of poisoning will counteract any evil effects.

† A discussion of this subject will be found in a work by the writer entitled "Potato Pests," pp. 69–75.

‡ An easy way of testing the purity of Paris green is to put about 100 grains in an ordinary wine glass and add thereto an ounce of liquid ammonia. In proportion as there is little or no sediment the green may be considered pure.

pound to that quantity of water is more often used, and considered most satisfactory. This is sufficient for one acre of cotton, and the cost per acre of a single application, including labor, varies according to a number of circumstances, but ranges from 25 cents to 60 cents.* It pays to add two or three pounds of flour or starch to the mixture, not only because of the greater adhesiveness which they give to the poison (a very desirable object, especially in wet weather), but because, by their color, they help to indicate the quantity that has been distributed. In using flour it will be found advisable to mix it first in a bucketful of water and allow it to remain until it sours, the object being to prevent it from forming lumps.

When applied in powder the green must be mixed with other ingredients in order to render it sufficiently economical and avoid injury to the plants. These ingredients should be cheap and, as far as possible, adhesive. Of the various mixtures that are used to-day and that have come to my knowledge all may be considered good. The proportion of the green to the diluents should be as 1 to 25, though the mixture is often used stronger, or as 1 to 18. Flour, or plaster, or cotton-seed meal are used with equal success, or a combination of them, the proportion being immaterial. Finely-sifted wood ashes may also be used as a diluent, one of the most popular mixtures consisting of one pound of Paris green, 6 lbs. of wood ashes, and about 12 lbs. of flour. In all cases it is advisable to add a small proportion, say from one to two pounds to the above formula, of some finely-powdered material of still greater adhesive quality, as dextrine, or gum arabic, or slippery-elm bark, or rosin. The cost per acre of one application of the dry mixture varies from 50 cents to $1.75, according to the first cost of materials and different modes of application, or, again, to the size of the plants at the time of the application.

Five patents have been issued for different combinations with Paris green. In 1868 Mr. J. P. Wilson, of Illinois, took out a patent (No. 82468) for one part of Paris green and two of mineral paint to be used to kill potato-bugs. In 1871 Mr. Lemuel Pagin, of Niles, Mich. (patent No. 112732), claimed a mixture (Paris green, 2 lbs.; rosin, 2¼ lbs.; gum arabic or slippery-elm, ¼ lb.; wheat flour, 5 lbs.; middlings, 1 bush.) for the same purpose. In 1873 Mr. G. F. Whisenant, of Chapel Hill, Texas, obtained a patent (No. 134959, Paris green, ¼ lb.; arsenic, 1 lb.; lime, 26 lbs.; and flour 5 lbs.) for destroying caterpillars on cotton. In the same year Mr. Wm. B. Royall, of Brenham, Texas, obtained patent for the same purpose (No. 140079, June 17, 1873), the ingredients being Paris green, 1 lb.; cobalt, 2 ozz.; flour, 17 lbs.; powdered gum tragacanth, 3 ozz.; powdered licorice root, 6 ozz.; and subsequently still another (No. 151439, May 26, 1874, Paris green, 1 lb.; flour, 4 lbs.; cotton-seed meal, 16 lbs.) for the substitution in part of cotton-seed meal for ordinary flour.

*The present year, Paris green averaged about 17 cents per pound in Selma, Ala., and 40 cents in Columbus, Tex.

Regarding these patent mixtures it must be borne in mind that the value of Paris green with some dilutent as an insecticide had been widely made public before any of them were issued, and I can but repeat here previously expressed opinion* that "it is to be regretted that patents can be obtained at all for remedies of this nature after they have become generally known and rightfully belong to the public. When the discoverer of such a remedy does not see fit to patent it, no one subsequently has a moral right to, whatever speculative right he may possess. Fortunately, in this case the patentees cannot interfere with the public rights, and it is to be hoped that no planter, either of potatoes or cotton, will be induced by flaming circulars and threats to pay even one cent per one thousand acres, much less the demanded $20 per one hundred acres, for the privilege of using these patented mixtures. The very fact that so many patents have been granted for the same purpose, all of them having Paris green as a base, shows clearly that the patent covers only the particular combination. By ringing the changes on the different proportions of the several ingredients, a thousand of these patent remedies may be obtained; and any one who diverges but a fraction from the particular patented combination ceases to infringe upon it. It will therefore be utterly impossible for the patentees to enforce the penalty for infringement without proof that precisely the same ingredients and combination as patented were used; and to get such proof will, I take it, be no easy matter; for were it, we should hear of hundreds of thousands of prosecutions where now we hear not of a single one."

Experience has justified this advice, for, while immense sums have been paid by planters to some parties for the right to use Paris green mixtures, the patentees have been unable to get protection from the courts whenever they have sued for infringement in the independent use of them by planters. The letter of the law too often negatives the spirit of the law, and it seems that the Patent Office has been forced to issue the patents above alluded to on the ground and decision that any change in the compounds of a mixture makes of it, in law, a new substance.

Arsenic.—While commercial arsenic, salts of arsenic, and the various compounds of them are much cheaper than Paris green, yet this advantage is more than counterbalanced by the injurious property they possess, in a more or less marked degree, of scalding the leaves and causing the squares and young bolls to shed. Moreover, on account of their white color there is more danger of injury to man and animals in their use than in that of colored preparations, which are less likely to be mistaken for harmless substances. Great care and precaution are, therefore, necessary in applying these arsenic poisons. When applied in just the right proportions to kill the worms without injuring the cotton they are valuable substitutes for the more expensive Paris green, but unfortu-

* Sixth Mo. Ent. Rep., 1873, p. 21.

nately these proportions vary with each particular combination, so that they can be satisfactorily ascertained only by absolute experiment. In fact, experience would indicate that it is almost impossible to use arsenic in any of the forms considered under this head without producing a bad effect upon the squares. It is for this reason that the Paris green mixtures have held their own against the cheaper compounds, and most planters, even where these last are used, find it desirable to still mix a certain proportion of the Green with them.

Commercial arsenic, costing from 7 to 10 cents per lb., is applied in powder form at the ratio of ½ lb. to from 18 to 25 of any of the ingredients used with Paris green. Used in water, these arsenic compounds give less satisfaction because of the dangers to the plant already alluded to, which are then increased. It is an interesting fact that already in 1871 a patent was obtained for the use of arsenic against the Cotton-Worm by Mr. Thomas W. Mitchell, of Richmond, Tex., (No. 110774, January 3, 1871; reissue No. 5935, June 30, 1874; 92 grains of opaque arsenic, or 293 grains of transparent arsenic, to one pint of water).

A more complicated compound, "JOHNSON'S DEAD SHOT," has been patented by Judge J. W. Johnson, of Columbus, Tex. (No. 151666 June 2, 1874), consisting of 8 ozz. arsenious acid, 1 oz. cyanide of potassium, 8 ozz. dextrine, dissolved in 40 gallons of water. One of the claims for this compound was that the vapor of the cyanide of potassium even killed the moths which came in the vicinity of the plants that had been sprinkled with the "Dead Shot". Experience has shown that the claim was unwarranted, and, in fact, in the packages offered to the public, Judge Johnson did not adhere to the specification, being finally afraid to use the cyanide of potassium, and making a mixture composed of 3 lbs. of commercial arsenic, 1 lb. of starch, 1 lb. of salts of tartar, ground up together. This was made up in powder packages to be used at the rate of 5 lbs. to 500 gallons of water and sprayed by means of his patent sprinkler presently to be described. This was found to have the same drawback, common to arsenical mixtures, of injuring the plant, and the later packages, advertised under the name of "Johnson's Improved Dead Shot," put up in 4 lb. tin boxes and to be used at the rate of 4 lbs. to 500 gallons of water, consist (according to the inventor's own statement to me) of 2 lbs. of commercial arsenic with a due proportion of rosin, caustic soda, and sulphate of copper, all boiled together. This is sold at $1.25 per box. It has, however, proved too often unsatisfactory and inefficient, and Mr. Johnson has been obliged to add or recommend the addition of one pound of Paris green to the mixture.

ARSENIATE OF SODA.—This has the advantage of being perfectly soluble in water, but has the same disadvantages as commercial arsenic. For a number of years an arsenical compound has been advertised under the name of "Potato-pest poison," by the Lodi Chemical Works of Lodi, N. J. It is put up in pound packages, which are sold at $1 each, with directions to dissolve 4 ounces in 2 quarts of hot water, then pour into

a barrel containing 30 gallons of cold water, and use on the plants in as fine a spray as possible.

A patent (No. 151078, May 19, 1874) was obtained by Messrs. J. D. Braham and A. Robira, of Galveston, Texas, for their "TEXAS COTTON WORM DESTOYER," which is essentially the same as the Lodi preparation, and put up at the New Jersey works for the Galveston firm. Fifty grains of arseniate of soda and 200 grains of dextrine are to be dissolved in one gallon of cold water. The mixture was formerly sold at the exorbitant price of $1 per lb., and is now offered for 50 cents per lb. It is put up in packages of 60 and 100 lbs., and thus sold at a discount of 10 per cent. It is to be used at the rate of 4 ounces of the mixture to about 40 gallons of water, making the cost of one application per acre about 12½ cents. It has been extensively used.

Another "pest poison," also essentially the same as the Lodi preparation, but faintly colored with rose aniline, is put up by the Kearney Chemical Works of New York, in ½ lb. packages, sold at 50 cents, and to be dissolved in 60 gallons of water.

London Purple.

This powder is obtained in the following manner in the manufacture of aniline dyes. Crude coal-oil is distilled to produce benzole. This is mixed with nitric acid and forms nitro-benzole. Iron filings are then used to produce nascent hydrogene with the excess of nitric acid in the benzole. When distilled, aniline results: to this arsenic acid, to give an atom of oxygen which produces rose aniline, and quicklime are added to absorb the arsenic. The residuum which is obtained by filtration or settling is what has been denominated "London Purple," the sediment being dried, powdered, and finely bolted. The powder is, therefore, composed of lime and arsenious acid, with about 25 per cent. of carbonaceous matter which surrounds every atom. Experiments which I made with it in 1878 impressed me favorably with this powder as an insecticide, and its use on the Colorado potato-beetle by Professors Budd and Bessey, of the Iowa Agricultural College, proved highly satisfactory. I was, therefore, quite anxious to test its effect on the Cotton-Worm in the field on a large scale, and in the winter of 1878–'79 induced the manufacturers to send a large quantity for this purpose to the Department of Agriculture. The analysis made of it by Professor Collier, the chemist of the Department, showed it to contain:

	Per cent.
Rose aniline	12.46
Arsenic acid	43.65
Lime	21.82
Insoluble residue	14.57
Iron oxide	1.16
Water	2.27
Loss	4.07
	100.00

Through the liberality of the manufacturers, Messrs. Hemingway & Co., a number of barrels of this powder were placed at my disposal the past season and distributed to various observers and agents in Georgia, Alabama, and Texas. Early in the spring Mr. A. R. Whitney, of Franklin Grove, Illinois, found it to be a perfect antidote to the canker-worms which had not been prevented from ascending his apple-trees, and the experiments of those whom I had intrusted to make them on the Cotton-Worm, as well as those made under my own supervision, all showed that its effects are fully equal to those of Paris green. Like the latter it kills the worms quickly and does not injure the plants if not applied in too great a quantity. Farther, it also colors the ingredients so as to prevent their being mistaken for harmless material. Finally, its cheap price removes the temptation of adulterating the poison, as every adulteration would prove more expensive than the genuine article. It is even superior to Paris green, as, owing to its more finely-powdered condition, it can be more thoroughly mixed with other ingredients and used in smaller proportion. Experiments on a large scale have been made with the dry application at the rate of 2 lbs. to 18 lbs. of diluents, also at the rates of 1, $\frac{1}{2}$, $\frac{1}{4}$, and $\frac{1}{8}$ lb. to 18 of the diluents. The last proved only partially effectual, and in no case were the plants injured or the leaves even burned. In all but the last case the worms were effectually killed, but as the mixture, at the rate of $\frac{1}{4}$ lb. was applied with greater care and regularity than is generally had on a large scale, and also in very dry weather, the proportion of $\frac{1}{2}$ lb. to 18 of the diluents is most to be recommended. All higher proportions are simply waste of the material.

Like Paris green, it is not soluble,* but is much easier kept suspended in water than the former. If applied in this way some care has to be taken in stirring it in the water, as it has a tendency to form lumps, owing to its finely-powdered condition. Experiments on a large scale with this material diluted in water gave the following results: When used in the same proportion as Paris green, namely, 1 lb. of the poison to about 40 gallons of water, one experimenter reports that the leaves were slightly crisped, while four others report a perfect success, and no injury whatever to the plant. Experiments by myself and Mr. Schwarz showed that when applied in the proportion mentioned and thoroughly stirred up in the water the leaves were partly crisped, though by no means so much as by arsenic, even when applied in weaker solution. When used in smaller proportion, or at the rate of $\frac{3}{4}$ or $\frac{1}{2}$ lb. to 40 gallons of water, it did not burn the leaves and still proved effectual in destroying the worms. Repeated experiments on a smaller scale confirmed these results obtained on large fields, and also showed that the proportion may be still farther reduced, and when applied with great care and in very dry weather $\frac{1}{4}$ lb. to 40 gallons will kill. Still farther reduction in the proportion of the powder used gave negative results.

* The manufacturers can render about 13 per cent. of it soluble if desired.

I would, therefore, recommend the use of ½ lb. of this powder to from 50 to 55 gallons of water as the proportion most likely to give general satisfaction by effectually destroying the worms without injuring the plants.

All that has been said under the head of Paris green as to the desirability of adding a small quantity of flour or other substance to give adhesiveness to the liquid will hold equally true of London purple, but the latter has in many respects a great advantage over the former, especially in its greater cheapness, being a mere refuse which, from its poisonous nature, was a drug to the manufacturers and had to be gotten rid of by being dumped long distances out at sea. This substance can be put upon the market at the bare cost of transportation. It can be sold in New York at the low rate of 6 cents per lb., and there is no reason why it should not be obtained at any of the large shipping points in the South at figures ranging between 7 and 10 cents a pound. This means virtually that the cost of destroying the worms by this powder is reduced to such a minimum as to depend mainly on the labor and the other ingredients or dilutents employed; in other words, that, while the planters, as heretofore, were obliged to pay as much as $1 for the first cost of the active poison needed for one acre, and never less than 15 cents, he may now obtain it for from 3 to 5 cents.

London purple has this farther advantage over other arsenical compounds hitherto employed: Its finely-pulverized condition seems to give it such penetrating power that, when used in liquid, it tints the leaves so that cotton treated with it is readily distinguished at a distance, the general effect being quite marked as compared with any of the other poisons similarly applied. It seems also to be more effectually absorbed into the substance of the leaf, and is therefore more persistent. At the same time experience shows that it does not injure the squares any more than Paris green.

Pyrethrum Powder.

The insecticide and insectifuge qualities of the dried and finely-powdered flower-heads of different species of *Pyrethrum*, and the harmlessness of the powder to man, to other animals, and to plants, have long since been known. Used against various household pests under the names "Persian Insect Powder" or "Dalmatian Insect Powder," it has hitherto been put up in small bottles or packages and sold at such high prices as to preclude the idea of using it on a large scale in the field. The so-called Persian Powder is made from the flowers of *Pyrethrum carneum* and *P. roseum*, while that from *P. cinerariæfolium*, a native of Dalmatia, Herzegovina, and Montenegro, is more generally known as Dalmatian Powder. Some interesting experiments made during the year on different insects by Mr. William Saunders, of London, Ontario, show that the use of this powder may be satisfactorily extended beyond the household, while a series which I made in the summer of 1878 with the same powder on the Cotton-Worm showed it

to have striking destructive powers, the slightest puff of the powder causing certain death and the almost instant dropping of the worm from the plant. Repeated on a still more extensive scale the present year at Columbus, Tex., the powder proved equally satisfactory in the field.

Here, then, we have a remedy far exceeding any other so far known in efficacy and harmlessness to man and plant, and the only question in my mind has been to reduce its cost. There was some hope of doing this by ascertaining the destructive principle, and it is to Prof. E. W. Hilgard, of the University of California, that we owe the first accurate determination of the same. The following extract from a letter received from Professor Hilgard last September indicates the results of some of his experiments:

DEAR SIR: Yours of 22d is to hand. I have had Milco's product in hand for some time, and have tried it on various bugs both in powder and infusion. To understand the best manner of using it in each case, it must be kept in mind:

1. That the active substance is a volatile oil.

2. That said oil, under the influence of air, not only volatilizes, but is also oxidized, and thereby converted into an inert resin.

It follows from 1, that the pyrethrum is at a disadvantage when used in the shape of powder in the open air, especially when the wind blows; from 2, that it is of the greatest importance that the substance should be fresh, or should have been kept tightly packed, for the same reason that hops must be similarly treated.

Hence I find that Milco's fresh powder is of greater efficacy than the best imported, although some of the latter contains twice as much matter soluble in ether; but the extract from the "buhach" is a clear greenish oil, while that from imported powder, and especially that from "Lyon's magnetic"—ground-up refuse, stems, &c., as I take it—is dark and thickish, or almost dry and crumbly.

Like all volatile oils, the essence of pyrethrum is soluble in water to some extent, and the tea from the flowers, and to a less extent, that from the flower-stems and leaves, is a valuable and convenient insecticide for use in the open air, provided that it is used at times when it will not evaporate too rapidly, and that it is applied in the shape of spray, whose globules will reach the insect despite of its water-shedding surfaces, hairs, &c. Thus applied, I find that it will even penetrate the armor of the red scale bug—or rather, perhaps, get under it—so that the bug falls off dead, in a day or two. The hairy aphides are the most troublesome, and require a strong tea of the flowers, atomized. The diluted alcoholic solution can, of course, be made as strong as you please, and will kill anything entomological.

Some persons have tried the decoction, and have of course failed, as the oil is dissipated by boiling.

My own experiments and those of Professor Hilgard were made with the powder from plants grown in California by Mr. G. N. Milco, of Stockton, and this powder, when used fresh, I have found to be more powerful than the imported kinds. Mr. Milco, a native of Dalmatia, has been cultivating the *P. cinerariæfolium* in California in constantly increasing area for the past three years, and deserves great credit for his efforts in introducing it. The Californian product is put upon the market in neat bottles and packages under the name of "Buhach," and I am under obligations to Mr. Milco for the liberal supply which he has placed at my disposal free of cost, wherewith to carry on my experiments. Before considering the cost of using this insecticide in the cotton-field it will be well to summarize the results of these experiments.

Pure Pyrethrum powder, mixed with a small quantity of finely-powdered rosin, was applied to the under-side of the leaves by means of a small pair of bellows. Taking advantage of the direction of the wind, and using the bellows freely, all the upper leaves of the plants were found to be well powdered, and consequently almost all the worms upon these leaves received at least some particles. The smaller worms died in convulsions in from 10 to 20 minutes, according to their size, and to the quantity of powder they have received. Larger worms soon became uneasy, and finally fell to the ground, where they invariably died in from 5 to 24 hours.

Every attempt to restock with worms a freshly-powdered plant failed. They evidently do not like the smell of the powder, and throw themselves from the leaves until they either fall to the ground or reach a leaf which has not been powdered.

Diluted with flour in varying proportions from one part of each up to one part of Pyrethrum and ten of flour, it produced equally good results as when pure. Mixed with 16 parts of flour, it proved at first insufficient, but upon being kept in a tight glass jar for two weeks, it evidently gained in power, for it then proved almost as effectual as the stronger mixtures. The powder can be successfully sifted on the plants during cloudy days or during the evening when the worms are on the upper side of the leaves. On sunny days, or when the worms are just hatched, it is more necessary to apply it to the under side of the leaves, as it acts only when coming in actual contact with the worms.

A strong decoction of the powder applied to the leaves produced no effect; nor did the worms appear to suffer from eating leaves thoroughly soaked with this decoction.

An alcoholic extract of the powder, diluted with water at the rate of one part of the extract to 15 of water, and sprayed on the leaves, kills the worms that have come in contact with the solution in a few minutes. The mixture in the proportion of one part of the extract to 20 parts of water was equally efficacious, and even at the rate of 1 to 40 it killed two-thirds of the worms upon which it was sprayed in 15 or 20 minutes, and the remainder were subsequently disabled. In still weaker solution or at the rate of 1 to 50 it loses in efficacy, but still kills some of the worms and disables others. I confidently recommend, therefore, the alcoholic extract of Pyrethrum, diluted at the rate of 1 part of the extract to 40 parts of water, and sprayed upon the plants as an effectual remedy against the worm.

The extract is easily obtained by taking a flask fitted with a cork and a long and vertical glass tube. Into this flask the alcohol and Pyrethrum is introduced and heated over a steam tank or other moderate heat. The destillate, condensing in the vertical tube, runs back, and, at the end of an hour or two the alcohol may be drained off and the extract is ready for use.

Let us now briefly consider the approximate cost of using this mate-

rial at present figures. The powder is now selling in California at wholesale, in 8-lb. packages, at $1.25 per lb.; but from facts kindly communicated by Mr. Milco, it appears that he has raised as much as 647 lbs. to the acre, and that the cost of production, milling, &c., on a large scale, need not exceed 6 to 7 cents per lb., because in the experiments attending the introduction of the plant many obstacles and expenses incident to new enterprises have had to be met. The plant is wonderfully free from insect enemies and blooms all through the summer, and there seems no good reason why it should not grow in most of the Southern States.

Carefully estimating from the results of experiments made, it will require about one and three-quarter pounds of the Pyrethrum powder to go over an acre of cotton at medium height; in other words, that quantity of Pyrethrum to 20 lb. of flour or other diluents will answer the purpose. Such being the case, the question as to whether the Pyrethrum can be used as a substitute for Paris Green, London Purple, and other arsenical powders resolves itself in one of relative market price, and if Mr. Milco's estimates are warranted—and no one in the country is better able to state the facts or give the figures on the subject—the Pyrethrum may be produced as cheaply as even London Purple. It is a question which future experience alone can determine, but that the prospects are encouraging there can be no question, and it is highly probable that the planter in the future will make it a rule to grow a patch or a few rows of this most useful plant as a ready means wherewith to protect his crop from the worm whenever the occasion for so doing presents itself.

So far as experiments have been made there would seem to be a decided advantage in point of economy in the use of the crude powder, since, in the ordinary methods of spraying, 40 gallons of liquid are required for an acre, and to produce this amount of diluted extract of Pyrethrum at the above figures would require about 6 lbs. of powder. This diluted extract has the advantage, however, over every other liquid so far used that it contains no solid and obstructing particles. It may, therefore, doubtless be used in a much finer spray than any of the other poisons.

Kerosene Oil.

It is a well-known fact that this is a most powerful insecticide, and experiment has shown that a fine spray of kerosene applied to the leaves will kill all worms thereon in a remarkably short time. This deadly effect is produced by the contact, the smallest quantity of the oil applied to any part of the worm causing instant death. Unfortunately, however, the oil has the same pernicious effect on the leaves, and the difficulty of applying it in such fine spray as not to injure the plants, and at the same time touch every worm, has not yet been overcome. The same objection applies to the use of the oil mixed with water. An

attempt has been made to apply the oil in form of vapor by means of steam. There is no question but that the worms are effectually killed by this application, and, perhaps, without injury to the plant, but the machine necessary for the production of the vapor, which will be described below, is so ponderous and awkward as to be of no practical value.

When mixed with a sufficiently large quantity of wood ashes, kerosene can be applied to the leaves without damaging them, but the mixture cannot be sprinkled in particles small enough to have much effect on the worms. A patent was obtained by Mr. George W. Powell, of Halifax County, Virginia, in April, 1876, for the simple mixture of one-half pint of kerosene to one quart of fine, dry, well-sifted wood ashes. The patentee claims that by sprinkling or scattering this preparation lightly over the plants it will drive off or destroy insects of every kind without injury to the leaves.

When converted into soap by means of lye and boiling, kerosene, like any other oil, loses much of its deadly quality; hence its application in soap form has but little effect.

While kerosene is thus of little value for direct use on the plants, it is most valuable for destroying the worms that are in one way or another brushed off the plants, as already described (p. 54). It may be successfully used also in pans around lamps as a means of insuring the destruction of the moths attracted thereto.

Cotton-seed Oil.

This cheap product has almost the same deadly effect on the worms as the more volatile kerosene oil, but it also kills the leaves of the plant even when applied to them in the form of a fine spray. The same obstacles as those mentioned in connection with kerosene oil also render a successful application of this and other cheap oils impracticable. It occurred to me that by making a soap by using this oil and the ashes from cotton-seed hulls, which are so generally used for fuel in the manufacture of cotton-seed oil, we might obtain a liquid that could be sprayed upon the plant with good effect, thus, on the principle *similia similibus curantur*, employing the products of the plant itself as an antidote to its worst enemy, these products being easily obtainable at nominal cost at all points where cotton-seed oil and cake are being manufactured. The experiments made by Mr. Schwarz certainly show that there is a possibility of successfully utilizing these materials where they can be abundantly and cheaply obtained. A strong suds from this soap was found to destroy the young worms, but seems to have little effect on the larger or full-grown ones. In this respect it acted very much as any other strong soap suds would, and it cannot be said to have any advantage over other saponaceous compounds except in the cheapness and abundance of materials at command by planters in the vicinity of cotton-seed oil factories. Its efficacy is greatly increased by the addition

of a small proportion of London Purple or Paris Green, but it is more than probable that under ordinary circumstances this saponaceous mixture would prove more expensive and troublesome than the other mixtures already recommended.

Carbolic Acid.

The late Thomas Affleck was a firm believer in the efficacy of this substance in preventing the moth from depositing her eggs upon the plant, and strongly urged its use in his correspondence with me. The saponaceous compound has been more or less successfully used against many other insects, and, so long as the smell of the acid remained upon the leaves, the moth would doubtless avoid such leaves for others that had not been treated. Dr. Phares pretty thoroughly tried it, however, some ten years ago, without satisfactory results, and the fact that it is so commonly used in the South for the "Screw Worm" and as a general disinfectant, and is yet not employed against Aletia, is fair evidence that it has little value in this connection. My own experience in trying it for other worms is that it has little effect on the worm when made weak enough to be harmless to the plant.

Sulphur.

A machine for the application of the vapor of this mineral is described farther on; but, so far as I can see, the machine has not been used to any extent. Nor is it probable that sulphur vapor will destroy the worms when applied in the open air.

Extracts or Decoctions from various Plants.

There is a wide field for experiment in this direction, though those which have so far been carried on under my direction or independently by others, have so far given very unsatisfactory results. Mr. Schwarz carried on a series of tests with some of the more common and promising plants that grow in South Texas. Strong extracts of Poplar and Hickory leaves; of the leaves and berries of the Poke Weed (*Phytolacca decandra*); of Cocklebur (*Xanthium strumarium*); of Wild Hemp (*Ambrosia trifida*); of *Heliophytum indicum*, *Euphorbia marginata*, and *Sesbania vesicaria*, produced no effect whatever. Others that have a strong smell, like the different species of Goat Weed (*Croton texanum*, *C. glandulosum*, *C. lindheimerii*, *C. capitatum*, and *C. monanthoginum*), or poisonous properties like the different species of *Solanum* (*S. cornutum*, *S. elæagnifolium*, and *S. carolinense*), gave equally unsatisfactory results.

Strong decoctions of the leaves and green berries of the China tree (*Melia azedarach*) killed a portion of the young worms when copiously used in spray, but had no appreciable effect on the larger worms. The "Coffee Weed" (*Cassia occidentalis*), used in the same way, was less injurious, though evidently distasteful to the worms, and the same proved true of Jamestown Weed (*Datura stramonium*) and tobacco.

Yeast Ferment: Fungus Infection.

The fact that insects, like other animals, are subject to diseases of an epidemic nature and of a fungus origin has led some persons to hope and believe that the germs of destruction could be, so to speak, artificially sown among those which it was desired to destroy. Dr. J. L. LeConte, of Philadelphia, was the first in this country, so far as I am aware, to suggest the introduction and communication of such diseases at pleasure for the destruction of insect pests, in a paper read at the Portland (1874) meeting of the Association for the Advancement of Science. Dr. H. A. Hagen, of Cambridge, Mass., has recently elaborated the idea, and strongly recommended as a general insecticide the use of beer-mash, or diluted yeast, applied with a syringe or a sprinkler. I quote the following somewhat sanguine words from an article which he published in the June number of the *Canadian Entomologist:*

"Dr. Bail asserts that he has proved by many skillful experiments that four species of microscopical fungi are merely different developments of the same species. One of them, the fungus of the common house-fly, is the vexation of every housekeeper. The dead flies stick in the fall firmly to the windows, or anywhere else, and are covered by a white mold not easy to be removed. The second is the common mold, known to everybody, and easily to be produced on vegetable matter in a damp place. The third is the yeast fungus, a microscopical species, and the basis of the work done by yeast of fermentation. The fourth is a small water-plant, known only to professional botanists. Dr. Bail contends that the spores of the fungus of the house-fly develop in water in this last species, out of water in mold, and that the seeds of mold are transformed in the mash-tub into yeast fungus.

"The experiments made by Dr. Bail cover a period of more than a dozen years, since the numerous objections which were made against his results induced him to repeat again and again his experiments in different ways. I am obliged to state that even now prominent botanists do not accept Dr. Bail's views, which he maintains to be true and to be corroborated by new and sure experiments. This question, important as it may be for botanists, is without any influence regarding my proposition, as Dr. Bail has proved that mold sowed on mash produces fermentation and the formation of a yeast-fungus, which kills insects as well as the fungus of the house-fly. I was present at the lectures of Dr. Bail before the association of naturalists, in 1861, which were illustrated by the exhibition of mold grown on mash on which the fungus of the house-fly had been sown, and by a keg of beer brewed from such mash, and by a cake baked with this yeast.

* * * * * * *

"Dr. Bail has proved by numerous experiments that healthy insects brought in contact with mash and fed with it are directly infested by the spores of the fungus with fatal consequence. These facts, not belonging strictly to the main part of his experiments, were observed first by chance and later on purpose. The most different insects, flies, mosquitoes, caterpillars, showed all the same results. The experiments were made in such a delicate manner that a small drop of blood taken with an oculist's needle from the abdomen of a house-fly left the animal so far intact that the same operation could be repeated in two days again. Both drops examined with the microscope proved to be filled with spores of fungus.

* * * * * * *

"Considering those facts, which are doubtless true, and considering the easy way in which the poisonous fungus can always and everywhere be procured and adhibited,

I believe that I should be justified in proposing to make a trial of it against insect calamities. Nature uses always to attain its purposes the most simple and the most effectual ways; therefore it is always the safest way to follow nature.

"Beer mash or diluted yeast should be applied either with a syringe or with a sprinkler; and the fact that infested insects poison others with which they come in contact will be a great help. Of course it will be impossible to destroy all insects, but a certain limit to calamities could be attained, and I think that is all that could reasonably be expected. In greenhouses the result would probably justify very well a trial, and on currant worms and potato bugs the experiment would not be a difficult one, as the larvæ of both insects live upon the leaves, which can easily be sprinkled. But it seems to me more important to make the trial with the Colorado grasshopper. I should recommend to infest the newly-hatched brood, which live always together in great numbers, and I should recommend also to bring the poison, if possible, in contact with the eggs in the egg-holes, to arrive at the same results, which were so fatal to Mr. Trouvelot's silk-raising. After all, the remedy proposed is very cheap, is everywhere to be had or easily to be prepared, has the great advantage of not being obnoxious to man or domestic animals, and if successful would be really a benefit to mankind. Nevertheless, I should not be astonished at all if the first trial with this remedy would not be very successful, even a failure. The quantity to be applied and the manner of the application can only be known by experiment, but I am sure that it will not be difficult to find out the right method. I myself have more confidence in the proposed remedy, since it is neither an hypothesis nor a guess-work, but simply the application of true and well-observed facts. I hear the question—When all this has been known for so long a time, why was it not used long ago? But is that not true for many, not to say for all, discoveries? Most of them are like the famous Columbus egg."

It will be seen that Dr. Hagen attaches little importance to the present opinion and judgment of mycologists as to the non-identity of the several fungi alluded to. I have corresponded with some of the leading cryptogamists of this country on this subject, and they are quite unanimous in the opinion that there is no one "of the least reputation," to use Professor Farlow's words, who admits that there is any connection between the fly fungus, known as *Empusa muscæ* but belonging to the genus *Saprolegnia*, and the yeast fungus, *Saccharomyces cerevisiæ*. It is to be regretted, also, that more precision has not been used by Dr. Hagen in referring to these fungi, for the "common mold known to everybody" is most vague, since many different species of mold are recognized by specialists, while "a small water-plant, known only to professional botanists" is such an indefinite expression as to inspire little confidence in the thoroughness of Dr. Bail's experiments. Leaving to the specialist, however, the question as to the kind of relation existing between the lower forms of fungi intended to be referred to by Dr. Hagen, I felt that the suggestion coming from so eminent an entomologist was well worthy of practical trial. I took occasion, therefore, to experiment with beer mash by spraying and sprinkling it upon various plants that were to be fed in my vivaria to Lepidopterous larvæ. The principal larvæ thus experimented with were of *Papilio asterias*, *Danais archippus*, and *Pieris rapæ*. The results gave no encouragement to the hope that anything practical would result from the proposed remedy. The larvæ fed with equal avidity and went through their transformations as well as the

same species had done on repeated occasions without being treated to beer mash. An incident connected with these experiments which I made is, however, well worthy of being mentioned; because it shows how very easily single experiments may lead to false hopes and conclusions. A certain proportion of the last-named larvæ—the proportion differing in the different lots treated—perished before or while transforming to the chrysalis state. They became flaccid and discolored, and after death were little more than a bag of black putrescent liquid. I should have at once concluded that the yeast remedy was a success had I not experienced the very same kind of mortality in previous rearing of this larva, and had I not, upon returning to the field from which the larvæ in question were obtained, found a large proportion similarly dying there.

Though from this experience I had little faith in the value of the proposed remedy as against the Cotton Worm, I nevertheless took pains to have it tested both by Professor Smith in Alabama and Professor Willet in Georgia, sending a copy of Dr. Hagen's article to each, with the request that they make the experiments thorough and, so far as possible, in the open air. The experiments were made in each instance during the latter part of the season when the vitality of the worms was already considerably lowered, a condition which, in my experience with fungus diseases in insects, was eminently favorable for satisfactory trial. Professor Smith, who used the yeast ferment, had a similar experience with my own, the result being that the worms were not affected one way or another. Professor Willet's experiments, on the contrary, seem to indicate that a larger proportion of the worms treated with the ferment perished, as compared with those that were not so treated. I therefore quote his report in full, the experiments having covered a period from September 20 to November 6:

"On going to Montezuma, Macon County, Georgia, September 20, where the cotton caterpillars were said to be in abundance, it was found that they were for the most part "webbed up." Moreover, a Northeaster with rain set in which prevented operations in the field for several days. It was, therefore, determined to conduct the experiments within doors.

After the sun came out on the 24th, however, two attempts were made to operate in the field, with very interesting but unexpected results. The caterpillars being much scattered in the cotton-field it was thought best to collect them together. Accordingly, September 24, at 11 a. m., 330 were gathered and colonized on two rows of cotton, in the garden of Rev. A. J. Cheves, at whose house the experiments were made. They were placed, 165 on each row, 5 caterpillars to each stalk. Beer and diluted yeast were sprinkled, each over half of one of the rows. The other row was left undisturbed. The next day at 1 p. m. the caterpillars were examined and counted. No dead ones were found. Of the caterpillars, 80, sprinkled with beer, only 10 larvæ and pupæ were found; and of the 85 sprinkled with yeast only 13 larvæ and pupæ were found; only 23 out of 165 being accounted for. This deficit of 142 was very remarkable. It could not be explained by the rapid poisonous effects of the beer and yeast, for no dead were to be seen. And though many wasps and bees were attracted by the beer, only one larva was seen to have been attacked by them; a feeble one had been seized by a yellow-jacket (*Vespa germania*). The row, which had received no beer nor yeast

was then examined, and 53 larvæ counted, leaving 112 unaccounted for. It was suspected, then, that the caterpillars had deserted the cotton and crawled away in the night in search of better pastures. Accordingly, September 26, 53 caterpillars were placed on 12 stalks of cotton and sprinkled with beer, and 15 others on a row alongside, but not sprinkled. They were watched during the day; three or four fell to the ground, but did not crawl away; the others seemed not disposed to eat. A swarm of flies, bees, wasps, &c., came to suck at the beer, but did not disturb them, with one exception, as before. The next day 6 of the 53 sprinkled with beer were found; and 2 of the 15 not sprinkled. The remainder had without doubt decamped during the night. This hint should be remembered hereafter in future experiments in the field. Only the dead and wounded should be numbered as the victims of poison. The missing may be vagabond deserters.

The experiments, the results of which are given below, were necessarily conducted within doors. The materials employed to produce the yeast fungus were "yeast cake," brown sugar, and water. One pound of brown sugar to one gallon of water, with half of a "yeast cake," fermented readily, and was applied when in active fermentation. This is called hereafter beer-mash or beer. A portion of yeast cake mixed with flour and water also fermented quickly, and was applied diluted with an equal quantity of water. This is called yeast. Molasses or sirup can be substituted for the sugar.

On September 21, 28 caterpillars about half grown were placed in each of 3 paper boxes with tops. The 28 caterpillars in box No. 1 were supplied, as they needed, with fresh cotton leaves wet on one side with beer-mash. The 28 in box No. 2 were supplied, likewise, with cotton leaves wet on one side with yeast. The 28 in box No. 3 were supplied with cotton leaves wet with water to serve as a basis of comparison, these being in the natural state, except as to confinement, want of sun, and excess of moisture. September 23, 20 caterpillars were placed in each of three other paper boxes, larger and better arranged. The 20 caterpillars in box No. 4 were supplied with leaves wet with beer-mash; those in box No. 5 with leaves wet with yeast; and those in box No. 6 with leaves wet with water. The two series were duplicates, except that the last had better quarters.

They were cared for thus till September 27, when they were removed to Macon, Ga., where the experiments were concluded. All the larvæ except one webbed up by September 30; the first moth appeared in box No. 2, October 3, and the last one, in box No. 6, October 13. The influence of the cool weather is seen in the slowness of the transformation.

Only a few died in the larva state; and it was only when most of the moths had come out that a difference in the results of the boxes was observed. It was then seen that a considerable number failed to pass through the pupa state, and that the largest number so failing were of those that had been fed on beer-mash and yeast.

As this seemed to lend countenance to Dr. Hagen's theory, an effort was made to repeat the experiment with a new lot of caterpillars. A small number were procured from a field near Macon, October 14, and placed in two paper boxes. The 12 in box No. 7 were fed on cotton leaves wet with beer-mash, and the 12 in box No. 8 were supplied with cotton leaves. October 18 all in box No. 7 had webbed up, some having eaten little or no leaves, and none of them having consumed the leaves and beer-mash to any great extent. All were nearly full-fed when caught, and were very sluggish from the coldness of the weather. The first moth came out October 31, and the last November 5.

The results in full are shown in the following tabular form:

Experiments with beer-yeast on three series of cotton caterpillars.

Living larvæ.		Dead larvæ.	Became pupæ.	Became moths.	Total larvæ (dead) and pupæ.	Total loss of larvæ and pupæ.	Loss as larvæ.	Loss as pupæ.
FIRST SERIES.								
September 21.		*Sept.* 27.	*Sept.* 23 to 30.	*Oct.* 3 to 13.				
With beer	28	2	17	5	19	$\frac{14}{19}$ = 73 per cent.	$\frac{2}{19}$ = 10 per cent.	$\frac{12}{19}$ = 63 per cent.
With yeast	28	5	16	6	21	$\frac{15}{21}$ = 71 per cent.	$\frac{5}{21}$ = 23 per cent.	$\frac{10}{21}$ = 48 per cent.
With water	28	2	23	11	25	$\frac{14}{28}$ = 56 per cent.	$\frac{2}{25}$ = 8 per cent.	$\frac{12}{25}$ = 48 per cent.
SECOND SERIES.								
September 23.		*Sept.* 30.	*Sept.* 23 to 30.	*Oct.* 3 to 13.				
With beer	20	1	17	7	18	$\frac{11}{18}$ = 61 per cent.	$\frac{1}{18}$ = 5 per cent.	$\frac{10}{18}$ = 56 per cent.
With yeast	20	0	19	9	19	$\frac{10}{19}$ = 52 per cent.	0 = 0 per cent.	$\frac{10}{19}$ = 52 per cent.
With water	20	0	23	17	23	$\frac{3}{20}$ = 15 per cent.	0 = 0 per cent.	$\frac{3}{20}$ = 15 per cent.
THIRD SERIES.								
October 14.		*Oct.* 20.	*Oct.* 20.	*Nov.* 6.				
With beer	12	0	12	11	12	$\frac{1}{12}$ = 8⅓ per cent.	0 = 0 per cent.	$\frac{1}{12}$ = 8⅓ per cent.
With water	12	0	12	11	12	$\frac{1}{12}$ = 8⅓ per cent.	0 = 0 per cent.	$\frac{1}{12}$ = 8⅓ per cent.

It will be observed that the mortality, as shown in the 7th column, was considerable in all of the first three boxes, being 73, 71, and 56 per cent. for the beer, yeast, and water, respectively, and only somewhat less for the second series, being 61, 52, and 15 per cent. But the ratios of the deaths in boxes 1, 2, 4, and 5, where the leaves were wet with beer and yeast, to those in boxes 3 and 6, where water alone was used, is noticeably great in both series. The same may be seen in column 5, showing the moths that came out. In the first series, the moths that issued were 5, 6, and 11 for the beer, yeast, and water, respectively, and 7, 9, and 20 for the similar boxes of the second series, being only one-third to one-half as many for the beer and yeast as for the water. In the third series the mortality is small, and is the same for both beer and water. The larvæ, when introduced into these two boxes, were nearly full-fed, and sluggish from cold, and ate but little.

The caterpillars that died were all young. It is possible that their deaths may have been caused by their bodies being clogged by the viscidness of the beer and yeast. Unless the effects of the yeast fungus upon them in their natural conditions in the field are more decided, little good will be done in cutting short their ravages as caterpillars, for most of them will survive till the chrysalis stage at least.

The mortality occurred mainly in the pupa state, the vitality being sufficient to carry the larvæ through the first stage of life, but not through the second.

If the fungus produced any effect in these experiments, it did not appear to extend to the moth state, for the moths, on coming out, appeared as perfect and lively as the moths in a state of nature. Could they, however, have been watched through their natural lives, and the number and soundness of their eggs, and the resulting brood of caterpillars observed, the effects of the fungus might have been found to extend beyond the chrysalis, and might tend to the enfeeblement of the race, as in the Silk Worm in Europe.

Such are the facts. On the whole, the experiments cannot be regarded as yielding any determinate conclusion. The confinement of the larvæ in small boxes, without air and sun, and with an excess of moisture, was unlike the conditions of nature, and not conducive to health. The number of larvæ also was too small as a safe basis of induction. Had the colony in each box been increased from a quarter of a hundred to a full hundred, the percentages might have been much changed.

But the results are suggestive. The greater mortality of the larvæ fed on beer and yeast, and in two independent series, may be mere coincidences. But such coincidences challenge attention, and encourage a repetition of the experiments under more favorable circumstances, and on a larger scale.

Unfortunately the value of these experiments by Professor Willet is impaired by failing to take account of so large a number of the larvæ in each set of the first two series. A careful analysis of the table and of Professor Willet's own conclusions will show that the results are vitiated and that the inferences drawn are not warranted, since we do not get the percentage of loss of the whole number commenced with, but of only a portion.*

The great difficulty in the way of propagating such epidemic diseases at pleasure among plant-feeding insects is that, as past experience shows, there must be certain conditions of the insects favorable to the growth

*Noticing some of the discrepancies when preparing the MS. for the printer, we pointed them out to Professor Willet, from whom we received, after the above was in type, explanations which still further mar the results. The three pupæ in the second series that are additional to the number of larvæ commenced with, and treated with water only, were intruding larvæ, and not improbably the three lost sight of in the other two boxes; while at one time the minute red ants, so troublesome in the South, got into the boxes, and as they would naturally be most attracted to the larvæ sprinkled with beer or yeast, it is fair to presume that such larvæ suffered most from their attacks.

of the fungus, and the comparative rarity of these fungus epidemics indicates how seldom all these necessary conditions are presented. While, therefore, I am by no means as sanguine as Dr. Hagen of practical results flowing from his suggestions, they are nevertheless worthy of more extensive and careful trial than I have been able to give this year.

Machines and Contrivances for powdering.

Before applying any poison in powder form it must be mixed with some of the diluents already mentioned. This mixing, generally done by farmers in a most primitive way by simply stirring the poison into a kettle or wooden box full of flour or other dilutent, is a matter of no small importance, as the success or failure of the application largely depends on the way in which the mixing has been done.

Mr. George Little, of Columbus, Tex., has constructed a very simple and useful contrivance for mixing the ingredients. It consists of a barrel which has a longitudinal wooden axle projecting somewhat at each end. Five or six staves run through the barrel longitudinally, but do not project at either end, and on one side is an aperture large enough to admit the ingredients. When they are in, the aperture is closed and the barrel is placed over a large open box, or fixed in any way so that it can be revolved by means of a handle attached to the projecting axle. By this simple and cheap contrivance much labor is saved and a thorough mixing assured, while all possible danger which might be incurred by hand-mixing is avoided.

In the matter of applying the powder, many planters prefer simply to scatter it by hand, after the manner of seed-sowing, as being more economical and rapid than any other method in use. It has, moreover, the advantage that, if the plants are high enough, the poison can be applied to the under side of the leaves. Planters who use this method assert, upon inquiry, that no evil consequences have ever followed their handling of the mixture in this way, but it strikes me as being altogether too unsafe to be recommended.

The usual way of applying dry poison is to sift it over the leaves by means of an ordinary bread-sieve firmly attached to a handle three or four feet long. One or two layers of muslin should be placed in the bottom of the sieve to prevent a too rapid escape of the powder. With some practice in handling these sieves, the foliage of the plants can be pretty evenly dusted, but in general there is considerable waste of the poison by this method. One man can go over one acre per day, but if the plants are high enough, and the soil not too much softened by rains, the poison can be sifted by men on horseback. This secures a more even movement, and consequently less waste of material. Some have tried, with advantage, to dust two adjacent rows at once by means of a stick of suitable length with a sieve fastened to each end, the operator riding between the rows and tapping the stick gently, either with his hand or another stick.

An old sack, such as those used for table-salt, will do good service attached to the end of a stick, but the safest thing for use on a small scale is a perforated tin box (Fig. 37) with a double lid (for security when not in use), and having a handle three or four feet long. By taking the handle of the dust-box in the left hand and tapping the box with a stick held in the right, the poison may be rapidly and evenly distributed, not only on the upper surface of the leaves, but on the under sides as well, if the box is held within and among the plants.

A number of patents have been taken out for machines for dusting the plants with poison, but for some reason or other none have become popular, and I have not been able to learn that any of them are in use at the present time. The object of these machines is to distribute the poison more economically and rapidly than it is done by the simple sifting methods here mentioned. The reason of their not becoming popular is, perhaps, that they do not accomplish their object. The gain in the more economic use of the powder is not large enough to induce the planters to invest in them, especially where labor is cheap, as the employment of an additional hand is more satisfactory.

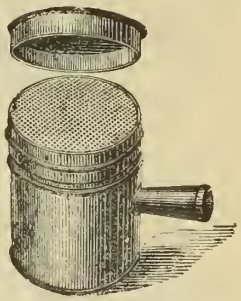


FIG. 37.—DUST-BOX FOR PARIS GREEN: upside down.

THE WILLIE DUSTER.—Mr. William T. Willie, of Brenham, Texas, has obtained a patent (No. 160986, March 16, 1875) for a contrivance which is but a modification of the method mentioned above of the application of the poison by a man on horseback by means of two sieves fastened to each end of a stick and carried across the saddle. The invention consists of two boxes suspended on a transverse bar, and made adjustable vertically and laterally according to the height of the plants and the width of the rows. The poison is dusted on two rows of plants by means of a system of vibrating sieves at the bottom of the boxes. The apparatus is intended to be secured to a riding-saddle in front of the rider.

In the annexed drawings, Fig. 38 represents a front view, Fig. 39 a sectional view, of the machine, the central figure showing a detailed section of one of the sifting-boxes.

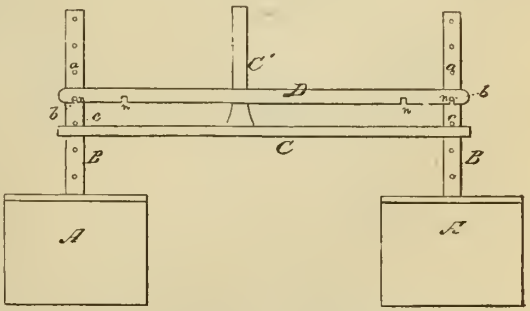


FIG. 38.—THE WILLIE DUSTER: front view.

The letters A A designate two boxes of any suitable capacity, which are constructed with two fixed sieves, *p p*, and movable sieves *p'*, arranged between the fixed sieves and supported upon rods, so as to slide freely when the boxes are vibrated and aid in pulverizing the material, and at the same time scattering it uniformly. The upper sieves *p* will support the bulk of the material free from the scattering sieves *p'*. Each box has secured to it a suspension-standard, B, having a num-

ber of holes, *a*, through it, arranged one above another, and adapted to receive suspension-pins *b c*, and allow the boxes to be adjusted vertically for high or low plants. C designates a bar, from which rises a guide-rod, C′. This bar C is intended to be secured by the middle of its length to the saddle, and through its ends holes are made through which the standards B B are passed and sustained by means of the pins *c c*. Supplemental holes are made through the bar C to allow the boxes A A to be adjusted for rows of plants varying in width. D designates a bar, the ends of which are slotted longitudinally to receive the standards B B, and at or near the middle of the length of this bar D a hole is made to receive freely through it the rod C′. The ends of bar D are notched at *n*, and are attached to the standards B B by fitting these notches over the pins *b b*, as shown in the figures.

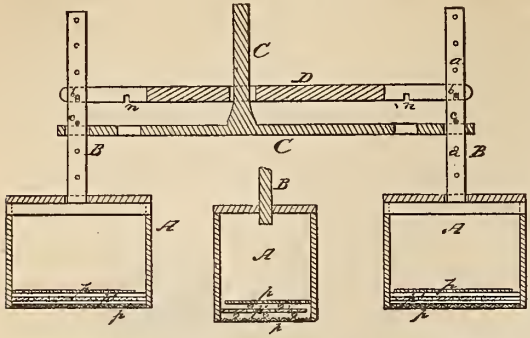


FIG. 39.—THE WILLIE DUSTER: sectional view.

THE HURD BLOWER.—A much more complicated apparatus is that invented by Mr. Charles T. Hurd, of Victoria, Tex. (Patent No. 145949, December 30, 1873). It is intended to be attached to a cultivator or similar machine, and is drawn over one row of plants at a time. It consists of a fan or blower, inclosed in a cylindrical casing, and conjoined with a box containing the poison. The powder is scattered over the plants by means of a vibrating wire screen or cloth at the bottom of the box, and at the same time converted into a cloud of dust by a current of air created by the fan already mentioned, and which is operated by a pulley or band running from the axle of the blower to a wheel on the supporting axle of the cultivator.

In the annexed drawings Fig. 40 represents a sectional elevation of the apparatus as attached to a cultivator, showing one end of the box A partly broken away; Fig. 41, a plan view, with a part of the blower-box removed; Fig. 42, a rear view of the blower-box and powder-box as attached to the cultivator axles.

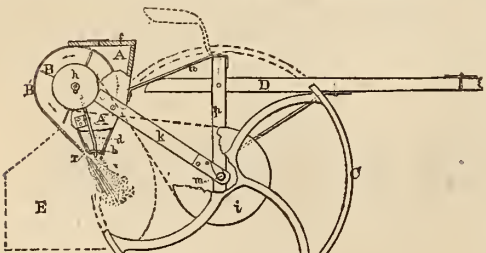


FIG. 40.—THE HURD BLOWER: sectional elevation.

A represents an oblong box, tapering to the bottom, which contains the powdered poison, having a flap or door, *f*, on its top, and opening at said bottom onto a wire screen or cloth, *b*, running from end to end of the box, which screen is oscillated lengthwise and across the row of plants by a lever, *d*, pivoted on one side of the box A, and engaged at the other end against a rotating cam, *e*, upon the axle of the blower B. A spring, *l*, keeps the lever engaged with face of the cam. The blower B is confined alongside of the box A in a cylindrical casing, B′, of a common form, and is mounted on a horizontal axle, *g*, which ends in a pulley, *h*, opposite to another pulley, *i*, upon the supporting-axle *m* of the cultivator.

The box A and the blower-box form one whole box, and is supported at either end by arms *k k*, which are centered upon the said supporting axles *m m* for the purpose of allowing the box A to be raised or lowered in the application of the powder. A ratchet or brace, *n*, for this purpose extends from the box A to a convenient part of the cultivator. The orifice *r* of the blower-box opens parallel with or close alongside of the oscillating screen *b*, so that the air current catches and directs the powder against the plants as it is shaken through the screen from the powder-box.

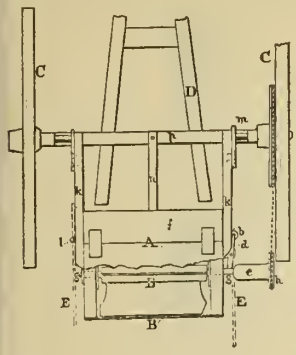


FIG. 41.—THE HURD BLOWER: plan view.

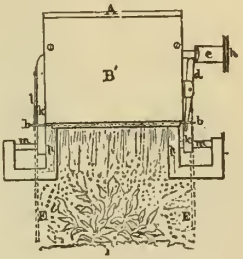


FIG. 42.—HURD BLOWER: rear view.

To confine the powder to the plants and vicinity, side-guards or hoods EE, of sheet metal or light wood, as shown by the dotted lines, may be advantageously employed, and be attached to the supports *k k* or other convenient part or place.

A seat may also be attached to the arch *p* or beams D D of the cultivator for the use of the driver.

It is evident that this apparatus neither saves material to any great extent nor time in the application of the poison, since only one row of plants is dusted at a time. The only possible advantage it can have is in so distributing the poison in a fine dust that it attaches to the under side as well as to the upper side of the leaves. Some suggestions made by the inventor as to the use of his machine for applying vapor and fine spray of liquid poison will be found mentioned further on.

THE ROBINSON DUSTING AND SPRINKLING MACHINE.—Several machines have been patented that apply the powder by means of revolving perforated cylinders. The oldest of these seems to be one invented by Mr. William T. Robinson of Huntsville, Tex. (Patent No. 146205, January 6, 1874). It combines both sprinkling and dusting, in that pure water is sprinkled over the plants by an arrangement in front of a two-wheeled truck, while at the same time the powdered poison is dusted from revolving cylinders attached to the rear part of the truck. The powder thus sticks to the leaves and may be applied at all hours of the day. Both the duster and the sprinkler can be detached at will and used separately if necessary.

From the accompanying Figs. 43 and 44, the former of which is a plan view, the latter a longitudinal sectional view of the machine, it will be seen that the dusting apparatus consists of an horizontal shaft G, extending each way beyond the wheels, for reaching over the outside rows, and carrying three or more revolving screens of sieves, H, for sprinkling on powdered substances. Said shaft is mounted on the rear end of the frame I, which is jointed to the truck at J, and suspended from the frame M by ropes L, which are wound up on the shaft N, or let out from it, to shift the screens according to the height of the plants. The shaft is revolved by a belt, O, from one of the wheels of the truck, working on cone-pulleys P O, for varying the speed of the screens or sieves, as may be required. The pulley O on the shaft G connects with it by a

clutch, R, which is connected with a shifting-lever, S, for throwing the shaft out of gear when turning around at the end of the rows, to save waste of material. T is a box for carrying the stock of powder, from which to replenish the screens or sieves, as

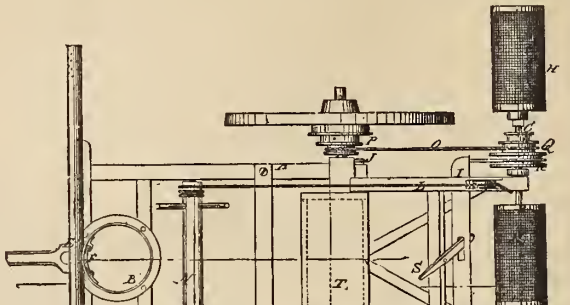


FIG. 43.—THE ROBINSON COMBINED DUSTER AND SPRINKLER: plan view.

they become exhausted from time to time. This box may be also used for a seat for the driver. The sieves are supplied through an opening in the ends, which may be closed by a gate or door of any kind, or by an opening in the side similarly closed.

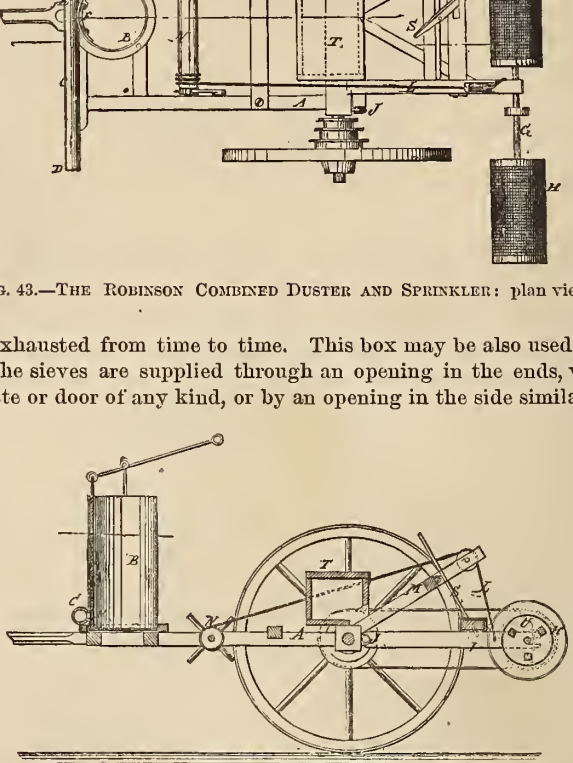


FIG. 44.—THE ROBINSON DUSTER AND SPRINKLER: longitudinal section.

THE DAVIS DUSTER—Invented by Mr. Nicholas A. Davis, of Rusk, Tex. (patent No. 154651, September 1, 1874.) This is almost an exact counterpart of the foregoing machine, but without the sprinkling attachment. The only peculiarity is the addition of springs to the revolving cylinders to prevent too great a discharge of the poison in case of a sudden jar.

In the accompanying drawings Fig. 45 represents the invention attached to a cart. Fig. 46 is a cross-section through the line *y y*.

A represents an ordinary farm-cart, across the rear end of which is secured the horizontal shaft B, having its bearings in the arms *c c*, projecting behind the cart. On the shaft B are placed two or more loosely-revolving perforated cylinders, E, being revolved upon the shaft, which carries a pulley, *a*, over which a band or cord works, passing to the hub of the cart-wheel, from which it receives motion, and thus causes the shaft B to revolve when the cart is in motion. Attached to the inner end of each of the outside cylinders is a spiral spring, *b*, coiled around the shaft A, and so arranged as to secure an easy, gentle, lateral motion to the cylinders in case of a sudden jar given the machine. A similar spring may be used at the opposite end of the cylinders, so as to check the jar in both directions. This invention can be fixed to any kind of frame moving on wheels, and by a hand-crank and ordinary cog-gearing be successfully worked.

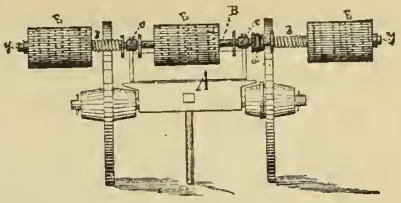


FIG. 45.—The DAVIS DUSTER: attached to cart.

FIG. 46.—The DAVIS DUSTER: longitudinal section.

THE LEVY DUSTER.—This duster, patented by Mr. Charles H. Levy, of Natchitoches, La. (No. 154690, September 1, 1874), also distributes the poison by means of revolving cylinders which can be adjusted to the heighth of the plant. The whole apparatus can be secured to the forward part of a saddle as well as to any cart. Fig. 47 is a front view of this contrivance, and Fig. 48 a side view of the same, partly in section through one of the cylinders.

AA are two cylinders, formed by attaching fine wire-gauze or finely-perforated sheet metal to circular ends or disks. To the inner surfaces of the cylinders A are attached longitudinal strips B, to one side of each of which is attached a strip, C, of tin or other suitable sheet metal, which strips thus form flanges, which, as the cylinders revolve, raise the compound and allow it to fall back so as to keep it stirred up and prevent the heavier ingredients from settling and thus escaping in too large a proportion and unevenly. The cylinders A are placed upon the end parts of a shaft, D, and are secured in place adjustably by keys or nuts, so that they may be moved toward or from each other to correspond with the distance apart of the rows of plants. Upon the middle part of shaft D is formed a crank, *d'*, by means of which the cylinders are revolved, either by taking hold of the said crank *d'* directly, or by a short handle, E, pivoted to said crank. The shaft D revolves in eyes in the upper ends of two bars, F, the upper parts of which are curved to give room for the crank *d'* to operate. The lower parts of the bars F are parallel with each other, and pass down upon the opposite sides of the standard G, to which they are secured by a bolt, H, which passes through a hole in the lower parts of the said bars F, and through a slot in the said standard G, so that by loosening the hand-nut *h'* of the bolt H the cylinders A may be raised and lowered, as the height of the cotton-plants may require.

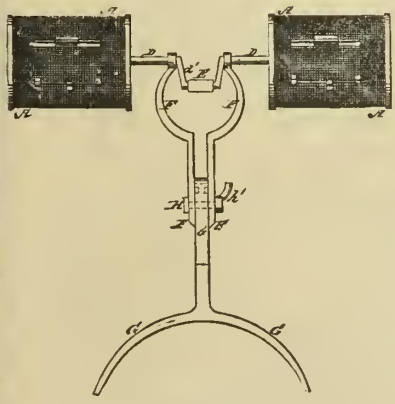


FIG. 47.—THE LEVY DUSTER: front view.

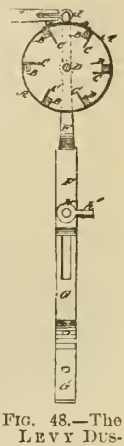


FIG. 48.—The LEVY DUSTER: side view.

The bars F may be kept from turning upon the bolt H by lugs formed upon the inner sides of the bars F, which enter the slot of the standard G, or by a second bolt.

The lower end of the standard G is branched, and has screw-holes formed through said branches to receive the screws or bolts by which the machine is secured to the forward part of a saddle, or to the frame of a sulky.

THE TAYLOR DUSTING AND SPRINKLING MACHINE.—Another machine, invented by Mr. Thomas B. Taylor, of Mount Meigs, Ala. (patent No. 214205, April 8, 1879), is somewhat similar to the Robinson machine already described in that it has arrangements for both sprinkling liquids and for dusting powders, and both can be used simultaneously or each separately. The dusting apparatus does not differ materially from the perforated revolving cylinders already described, but the machine is interesting because it is to be attached to a common plow-stock, so as to do the cultivating and the poisoning at one and the same time. Fig. 49 is a vertical longitudinal section, and represents the plow-stock with both the sprinkling and dusting arrangements attached to the same.

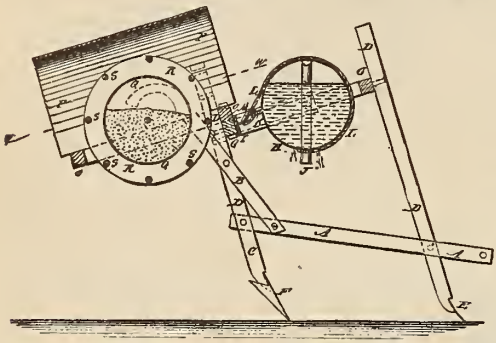


FIG. 49.—THE TAYLOR DUSTING AND SPRINKLING MACHINE.

A represents the beam, B the handles, and C the standard of an ordinary plow-stock. To the forward and rear parts of the beam A are rigidly attached two standards, D, the rear one of which may be the upward extension of the plow-standard C. The lower end of the forward standard, D, extends to or nearly to the ground, and has a plow-plate, E, attached to it to assist the plow-plate F attached to the plow-standard C in cultivating the ground, and to give steadiness to the machine, so that it may be readily controlled. To the upper parts of the standards D are pivoted the centers of the long front and rear bars of the rectangular frame G to the centers of the short side-bars, of which are pivoted the ends of the sheet-metal cylinder H. This cylinder represents the sprinkler, and a more detailed description of it will be given under the proper head. It can be detached, and the dusting arrangement which, in the figure, is represented as secured to the rear of the frame G can be put in its place. This dusting arrangement consists of a frame, O, similar to G, and to it are secured two semi-cylindrical plates, P, with their convex sides upward, and with their inner side edges near and upon the opposite side of the handles B. In bearings in the opposite sides of the two plates P revolve the journals of two cylinders, Q, made of finely-perforated sheet metal or fine wire-gauze to sift the dry powder poison upon the plants.

The sifting-cylinders Q are designed to be revolved by contact with the plants. The ends of the cylinders Q are provided with ring-flanges R, to which are attached the ends of a number of rods, S, to strike against the plants and revolve the said cylinders. The rods S prevent the surfaces of the cylinders from being wet by moisture from the plants, which would cause the powder to stick to them and thus clog the discharge-holes.

The two sifting-cylinders, as well as the sprinkler, project of course on each side of the plow and distribute the poison on the two adjacent rows between which the plow is drawn.

THE ALLEN DUSTER.—Invented by Mr. Samuel L. Allen, of Philadelphia (patent No. 178704, June 13, 1876). This machine applies the powder by means of a pair of bellows mounted on wheels.

THE YOUNG DUSTER.—Invented by Mr. James W. Young, of Southfield, Mich. (patent No. 188219, March 6, 1877). This is an apparatus carried across the shoulders of a person between two rows of cotton. The poison is applied by means of perforated cylinders which are set in motion by the bearer by means of crank-handles.

THE GOODHEART DUSTER AND SPRINKLER.—This machine, invented by Mr. James Goodheart, of Matawan, N. J. (patent No. 204720, June 11, 1878), works on the same principle as the Taylor and Robinson machines. The dusting apparatus consists of a box with a screen bottom, the whole being agitated by means of a lever connected with one of the wheels. The sprinkler consists of a transverse pipe with a number of of holes at its lower forward side. The machine is drawn over but one row of plants.

Machines and Contrivances for sprinkling or spraying.

For the sake of convenience the contrivances for the use of liquid poisons are here divided into those intended to be used on a small scale, covering one or two, rarely three, rows of cotton at once, and those that can be used to advantage on large fields and which cover from three to nine rows or more at once. In the first class the liquid is distributed by its natural pressure as in a garden sprinkler, while in the second class, or those intended to be used on large fields, there is always a pump, which supplies the pressure necessary to produce and throw the liquid upon the plants in the form of spray. Several of the machines here described do very good work in the field, and are strongly to be recommended. Their principal disadvantage lies in the fact that in wet weather it is often impossible to use them in a field on account of their weight. One great desideratum of any horse-sprinkler should, therefore, be lightness, and the machine which most combines lightness with cheapness and ease of management will naturally be most sought for.

FIG. 50.—GRAY'S IMPROVED SPRINKLER.

THE GRAY SPRINKLER.—For applying the liquid poison to the leaves of the plants a common watering-pot will be found to do good service on small patches of cotton. Still better for small fields is the sprinkler constructed by Mr. Frank M. Gray, of Jefferson, Ill., for sprinkling two rows at once. (Fig. 50.) It consists of a can, capable of holding about eight gallons of liquid, and so formed as to rest easy on the back, to which it is fastened, knapsack-fashion, by adjustable straps, which reach over the shoulders and fasten across the breast. To the lower part of the can are attached two rubber tubes, which are connected with two nozzles or sprinklers. The inside of the can has three shelves, which help to keep the mixture stirred. There is a convenient lever at the bottom which presses the tubes and shuts off the outflow at will, and two hooks on the sides near the top, on which to hang the tubes when not in use. On the top is a small air tube and a capped orifice.

THE RUGGLES SPRINKLER—Invented by Mr. Silas Ruggles, of Three Rivers, Mass. (patent No. 203072, April 30, 1878), is an exact counterpart of Gray's Sprinkler, with the addition of a stirrer, agitated by the movement of the arm of the bearer.

THE RAMSEY SPRINKLER.—Mr. Croghan A. Ramsey, of Schulenburg, Tex., has obtained a patent (No. 163526, May 18, 1875) for the very simple contrivance which is illustrated at Fig. 51. It consists of a box or vessel, A, large enough to hold about five gallons. It is provided at its top with a receiving funnel, *a*, for the liquid. At the bottom or on the front side near the bottom, and near each end, are two flexible tubes or rubber hose, B, provided with nozzles, *b*. This device is intended to be strapped upon a horse's back, to the cantle of a saddle, with the tubes in front. The front of the vessel A is inclined backward, so as not to interfere with the movements of the rider; and a pad, C, may be placed under it, so as to cause it to rest easy upon the horse. The nozzles, when not in use, are held above the top of the box by means of hooks, *c*, which seize over rings, *d*, upon the top corners of the box, so as to prevent the liquid from flowing out. When in use, the rider takes a tube in each hand and proceeds to sprinkle the rows on each side.

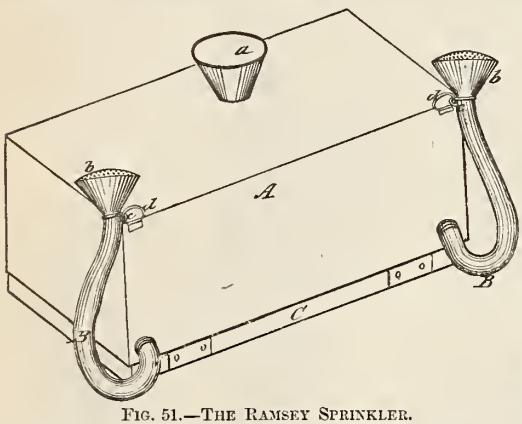


FIG. 51.—THE RAMSEY SPRINKLER.

The sprinkling apparatus of the Taylor Dusting and Sprinkling Machine described and figured on p. 83 should be mentioned in this connection. The accompanying Fig. 52 gives another representation of this machine, but with the dusting arrangement detached. Leaving out

those parts that have been already described, this sprinkling apparatus may be explained as follows:

The letter I represents a metal strap, attached to the rear bar of the frame G, with the end parts bent forwards at right angles and with holes to receive the journals of the cylinder H, the arms of the strap thus serving as springs to keep the cylinder in place. By a simple arrangement, indicated in the figure, the frame G may be adjusted higher or lower to the standards D, according to the height of the plants. In the upper side of the cylinder H are formed a number of small holes, through which the liquid poison escapes to the plants. In the center of the perforated side of the cylinder H is formed a hole in which is secured the tube J, through which the poison is poured into the said cylinder. The inner end of tube J is soldered in part to the inner surface of the opposite side of the cylinder H to prevent it from being loosened by the pressure of the liquid. In the sides of the inner end of the tube J are formed holes of such a size that the liquid will readily pass out of the said tube into the cylinder H. To the rear side of cylinder H are attached loops, K, to which are attached cords, L, which pass through eyes, M, or around pulleys attached to the rear bar of the frame G. From the eyes or pulleys M the cords L pass over the cylinder H, and are attached to the projecting end of the tube J. The cords L serve to secure the cylinder H in place and limit its movement when turned upon its journals. One or more balls, N, may be placed in the cylinder H, which, when the cylinder becomes empty, make a noise, and thus notify the operator.

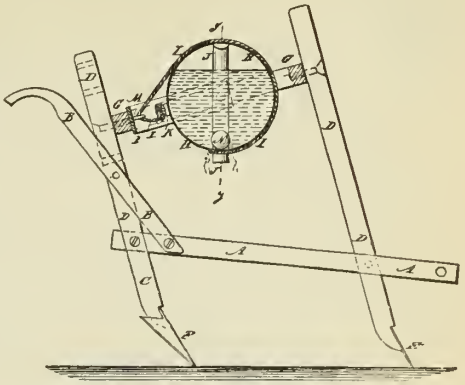


FIG. 52.—THE TAYLOR SPRINKLING APPARATUS.

If desired, the cylinder H may be rigidly secured to a single bar, G, attached to a single standard, D. In this case holes must be formed also in the upper side of the cylinder H. The holes in the upper side let the air escape in filling, and admit air to cause the liquid poison to flow out through the lower holes. This construction is a little simpler and cheaper than the other, but causes a slight waste of the poison, as some of the poison will flow out through the lower holes while the cylinder is being filled.

The operator may be protected from the poisonous liquid by cloth screens placed upon the opposite sides of the handles B, and attached at their upper and lower edges to two pairs of rearwardly projecting bars attached to the frame-work of the machine.

The sprinkling apparatus mentioned in connection with the Robinson Dusting and Sprinkling machine, described and figured on p. 77, consists of a tank, B, for holding the liquid, and of a sprinkling tube, C, connected with the tank and extending across the frame and beyond far enough to reach the two outside rows. This tube has small perforations, D, at the ends, and also at the middle, E, for sprinkling the liquid upon three rows of cotton. A gate or valve, F, is arranged in the tank to shut off the liquid from the tube or to regulate the discharge. The end of the tube is to be closed with a cap or plug, so that it can be opened and the perforations be cleaned out.

THE TOWNSEND SPRINKLER.—This was invented by Mr. George Townsend, of Greenville Centre, N. Y. (patent No. 212412, February 18,

1879), and is intended, like Gray's Sprinkler, to be carried on the back of a person. It consists of a tank, with a stirring arrangement, but has only one sprinkling tube, and sprinkles, therefore, only one row of plants.

THE WILLIE SPRINKLER—Invented by Mr. Wm. T. Willie, of Independence, Tex. (patent No. 158345, December 29, 1874), sprinkles two rows of cotton by means of an arrangement very like a common garden sprinkler, one of which is secured on each side of a frame fastened across a saddle.

THE SCHANCK SPRINKLER.—This sprinkler, invented by Mr. Lafayette S. Schanck, of Marlborough, N. J. (patent No. 215683, May 20, 1879), consists of the barrel with a stirring apparatus and with two or more pipes connected with the bottom of the barrel, each having a finely perforated nozzle. The whole apparatus is placed on a cart.

FIG. 53.—PECK'S SPRAY MACHINE.

PECK'S SPRAY MACHINE.—A very good portable spray machine has been invented by Mr. W. P. Peck, of West Grove, Pa. (Fig. 53) consisting of a tank strapped knapsack-fashion on the shoulders, and connected by rubber tubes with a pair of bellows, buckled to the waist, turned by a crank, and connected with a movable nozzle. The tank holds three gallons, and there is a simple device at the bottom, which, by the motion of walking, keeps the liquid in agitation and prevents the poison from settling. The liquid issues in a fine spray and with considerable force.

Mr. Charles T. Hurd, of Victoria, Tex., whose machine for dusting has been described and figured on p. 76, Fig. 40, suggests in his claim that

by changing the oscillating screen *b*, and inserting a perforated bottom in the box A, and charging the same with poisonous liquid, the latter may be atomized by the current of air originated by the blower, and thus applied to the row of plants over which the apparatus is drawn.

It is evident that these devices, while useful in a small way, are insufficient for large fields. Whenever it becomes necessary to protect the cotton, success often depends on the rapidity with which the work can be done; else the worms may totally destroy parts of a plantation before the planter manages to prevent it. Hence the importance of machines which apply the remedy to several rows at once.

Before describing these machines, it may be mentioned that the FOUNTAIN PUMP, manufactured by Mr. Josiah A. Whitman, of Providence, R. I., has been extensively used in the South for applying liquid

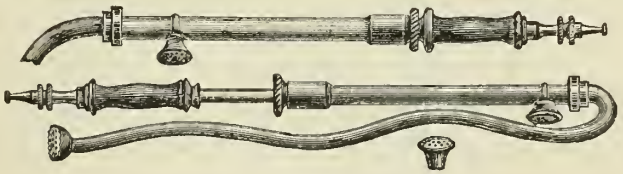


Fig. 54.—FOUNTAIN PUMP.

poison. These fountain pumps (Fig. 54) are too well known to need any further description. They are sold in the South for about $10 apiece, including the rubber hose. The most common mode of using them is the following: A barrel containing the liquid is put on a cart or wagon and drawn over the field. One hand is employed, if necessary, to keep the poison stirred up, while three others, each with one of these pumps, apply the liquid from the rear of the wagon, one taking charge of the three inner rows, the others each about three more rows on either side. In the use of this and of all other pumps it is advisable to add a strainer to the lower end of the hose in order to prevent impurities from entering the valve. In an emergency, where no machines are at command, these fountain pumps do excellent service, and many prefer them to other means of applying the poison. They are, however, wasteful of material, and the poison is more apt to get on to the bodies of those employed in their use than in most of the other modes of sprinkling.

Most of the machines used for throwing liquid on a large scale, whether patented or not, are modifications of one and the same idea and principle, viz, a barrel or other vessel to contain the liquid, a vehicle to carry it, a force-pump firmly secured to the top of the barrel, and a distributing nozzle, or several of them, connected with the discharge-pipe. The differences they exhibit are found principally in the nature of the distributors, the most successful ones being those which least clog, since it is almost impossible to get such pure water that there will not be some clogging material, even where strainers are used.

THE GOODIN SPRINKLER.—This machine, invented by Mr. James L. Goodin, of Montgomery, Tex. (patent No. 198014, December 11, 1877), is represented by the accompanying cuts. Fig. 55 is a top view, and

Fig. 56 a side view of the same. The letter A represents a tank or any other vessel to receive the poisoned liquid.

In the lower part of the forward end of the tank A is secured a discharge-pipe, B, the inner end of which is provided with a valve or ordinary sirup-faucet. The stem C of the valve or faucet passes up through a hole in the top of the tank A, and its upper end is pivoted to the end of a lever, D, which is

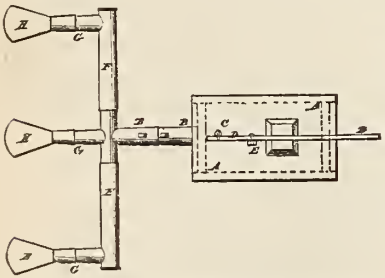


Fig. 55.—THE GOODIN SPRINKLER: top view.

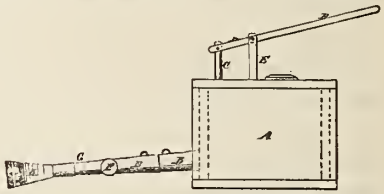


Fig. 56.—THE GOODIN SPRINKLER: side view.

pivoted to a short standard, E, attached to the top of the tank A.

To the forward end of the pipe B is attached a cross-pipe, F, from the forward side of the center and ends of which project short pipes, G, having heads, H, attached to their forward ends. The heads H are perforated with numerous small holes. The pipes B F are jointed as shown in the drawing, so that they may be lengthened or shortened as circumstances may require.

THE YEAGER SPRINKLER.—This is a sprinkler invented by Mr. George Yeager, of Flatonia, Tex. (patent No. 204410, May 28, 1878). Fig. 57 is a part sectional side view, and Fig. 58 a plan view thereof.

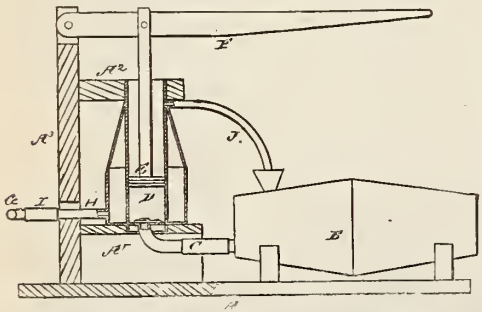


FIG. 57.—THE YEAGER SPRINKLER: side view.

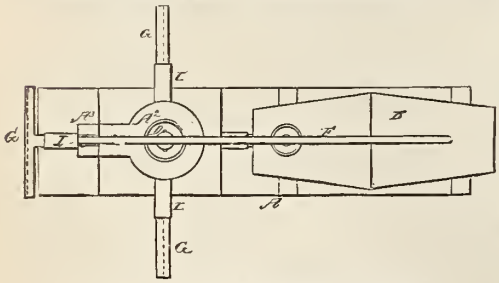


FIG. 58.—THE YEAGER SPRINKLER: top view.

It consists of a platform, A, upon which is laid a barrel, B, containing the poisonous liquid. A rubber hose, C, connects this barrel with the bottom of a pump-cylinder, D. This cylinder is supported on a step, A^1, and its upper end held in a brace, A^2, attached to a standard, A^3, which rises from the platform A. E is the pump-plunger, connected to a lever, F, which is pivoted in the upper end of the standard A^3. The liquid poison is forced out through the sprinklers G G G, which are three in number, and throw the water in a fine mist over three rows of cotton. A rubber hose, I, is attached to each of the spouts H of the pump to form connection with the sprinklers G, for the purpose of lengthening or shortening the spouts, especially the two on opposite sides of the pump, and of detaching and cleaning the sprinklers. The upper end of the pump-cylinder is left open and a spout or tube, J, is connected thereto to conduct the liquid, which would otherwise be wasted, back into the barrel.

The connection of this waste-pipe with this machine is the only point which is claimed as new by the inventor. The sprinklers or nozzles are

not further described, but it is to be understood that the spray is produced in the same way as described in this class of sprinklers.

THE RUHMANN SPRINKLER.—Invented by Mr. Julius P. Ruhmann, of Schulenburg, Tex. (patent No. 206901 August 13, 1878). This does not differ in any essential respect from the machines just described.

Fig. 59 is a longitudinal section of the machine; Fig. 60 shows the connection of the pump-cylinder with the air-chamber; Fig. 61 represents the strainer; Fig. 62, the nozzle, showing the arrangement for cleaning the same; and Fig. 63 shows a modification of the discharge-pipe.

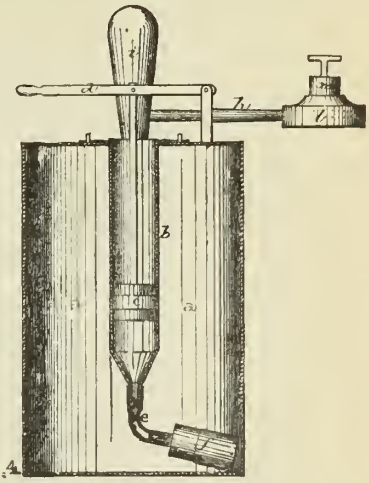


FIG. 59.—THE RUHMANN SPRINKLER: longitudinal section.

The letter *a* prepresents the reservoir for holding the poisonous liquid; *b* is the pump-cylinder, in which the piston *c* is worked up and down by means of the lever *d*. The lower end of this cylinder is made funnel-shaped, and to it is fastened the rubber tube *e* which connects it with the strainer *f*. This strainer is made in two parts for the introduction of a straining-cloth, *g*, and for convenience in cleaning. The lower end of the strainer is perforated, and, if desired, any additional straining matter may be placed between the perforated bottom and the cloth, so as to make sure that no substances shall be forced into the sprinkler to clog its action. To the lower end of the cylinder is secured the discharge-pipe *h*, upon the top of which is formed the air-chamber *i*. Upon the outer end of the discharge-pipe is placed the sprinkler *l*, which is round and flat, as shown, and perforated about one-half around. Upon the top of this sprinkler is screwed the cap or cover *m*, secured to which is the brush *n*. The handle of the brush is bent at right angles, as shown, and is secured to the cap in such a manner as to form, as it were, a part thereof, so that as the brush is moved around to clear away any obstructions which may have a tendency to close up the fine perforations in the edge of the sprinkler the cap turns with it. By means of this screw-cap the brush can be adjusted up and down at will, so that after cleaning off the perforations the brush can be depressed down below the level of the holes, so as to be out of the way.

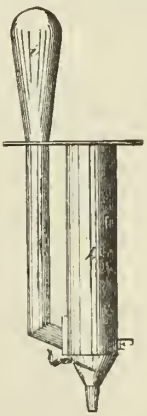


FIG. 60.

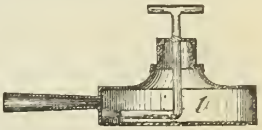


FIG. 62.

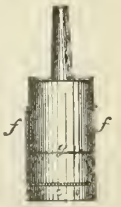


FIG. 61.

FIG. 63.

RUHMANN'S SPRINKLER: parts referred to.

Instead of a single nozzle, there may be two or more used by simply changing the construction of the discharge-pipe, as in Fig. 63, which represents one made for the use of three nozzles.

Several other machines of this class have been patented, but as they are mere repetitions of those already described, and the patents have been obtained on slight changes in the pump and in the arrangement for cleaning the nozzles, it is sufficient to merely mention those that have come to my knowledge. Mr. J. C. Melcher, of Black Jack Springs, Tex., has constructed one, and obtained a patent for the nozzle January 18, 1879. It is of the same shape as that of Mr. Ruhmann, but without the brush, and the cleaning is done by unscrewing the upper cover of the nozzle. Another of very similar nature is the improved sprinkler of Mr. G. Jeager, of Flatonia, Tex., for which a patent was applied for last April.

If the pump of these machines is made of good material, so as to give and stand a good deal of pressure, and if the nozzle is of sufficient size, or if several smaller nozzles are used, a fine and efficient spray can be thrown over from five to seven rows of cotton when the wind is favorable. In this way about 40 acres can be sprinkled in one day. The price of these machines ranges from $6 to $9, and they do good work, the principal difficulty being found in keeping the nozzles clean.

THE JOHNSON SPRAY MACHINE.—This sprinkler, invented by Judge Jehu W. Johnson, of Columbus, Tex. (patents No. 145571, December 16, 1873, and No. 145572, of the same date), is not only the oldest one on record for the application of liquid poison on a large scale, but produces the spray in a novel and peculiar manner.

The accompanying sketch represents this machine in operation. It will be seen therefrom that it consists of a tank placed upon a two-wheeled cart. The pump secured to the top of the tank is a common double-acting force pump, and with the discharge-pipe is connected a transverse pipe. These parts need no further description, and nothing new or peculiar is claimed for them. The claim for the second patent mentioned above is based upon the addition of a self-acting pitman, the arrangement of which can be seen in the sketch, and which is more fully illustrated at Fig. 65. The letter A represents the tank, B the platform of the cart, which is provided with the two wheels, C. These are much smaller than ordinary cart-wheels, in order to give the required number of revolutions necessary to the successful operation of the pump. In order to place the cart-bed at such an elevation as to pass over the rows of plants, it is raised by means of vertical bars, as will be seen in the sketch. One of the wheels C has a crank-pin, *c*, attached to it, at a suitable distance from the center, and to this crank-pin is attached the lower end of a pitman, the upper end of which is attached to the pump-lever G. The discharge-pipe of the pump is provided with a valve to regulate the flow of the liquid. With the transverse pipe before mentioned are connected, by means of screw-joints, branch pipes K, which in the sketch and in the diagram are five in number.

These branch pipes are made of cast metal, and on their inner surface, at the lower end, grooves, *l*, are formed, either during the process

of casting or by planing or cutting them out afterwards. In the lower end of these branch-pipes a plug made of rubber or cork is inserted, and a rod extends from the plug to the upper end of the tube *k*, where

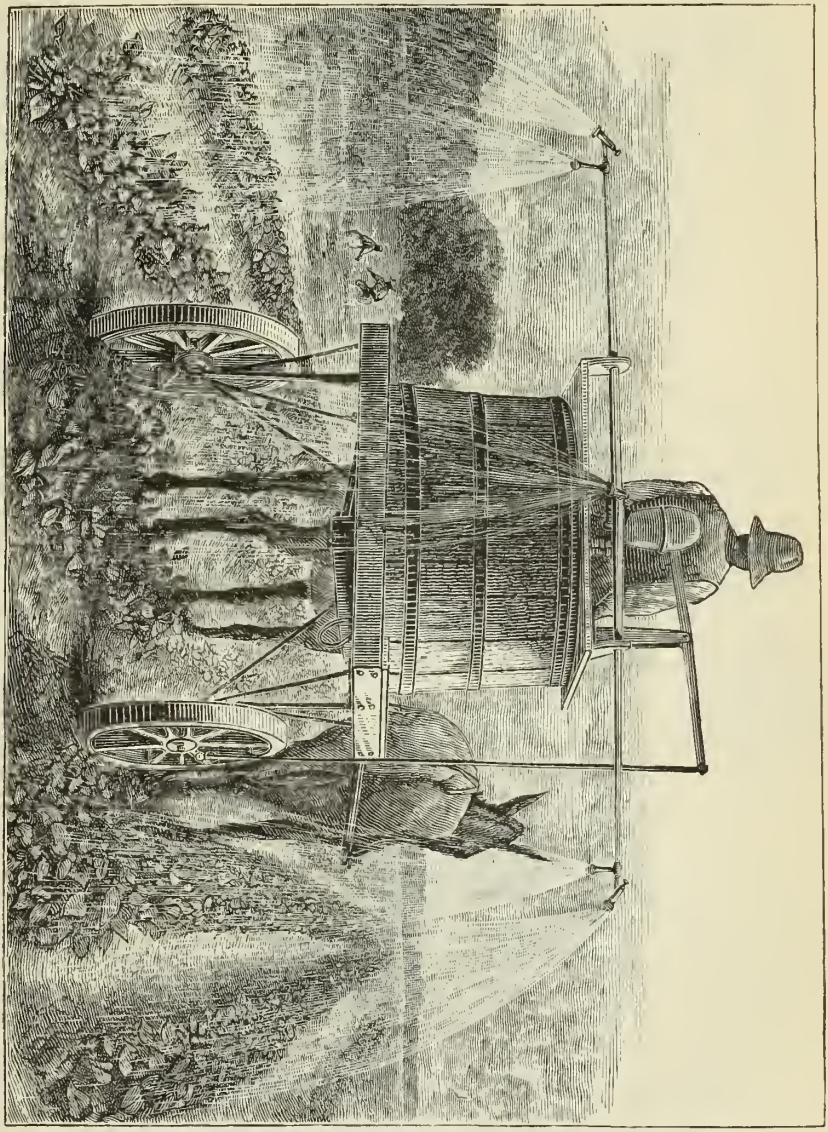


Fig. 64.—Johnson Spray Machine: in action.

it engages with a nut by which the plug may be tightened or loosened. It will be seen that the liquid passing through this pipe must escape by way of the grooves and assume the form of spray, and that by tightening or loosening the plug the size of the grooves is increased or diminished.

This machine makes a remarkably fine spray, but it possesses the same disadvantage as those already mentioned, namely, the ease with which the nozzles clog, notwithstanding the receiving-pipe of the pump is provided with a strainer. This I found to be a serious drawback, requiring frequent stopping of the driver and his dismounting to remove, cleanse, and readjust the plugs. The addition of the self-acting pitman has proved less useful than one would suppose, for Judge Johnson himself writes me that "experience has demonstrated the fact that it is about as easy and far more economical to work the pump by hand-power than to use the pitman rod." By dispensing with it, the tank may be placed on any cart without special construction. This machine has been considerably used, but its price ($65 without the cart) is very high when compared with that of others here described.

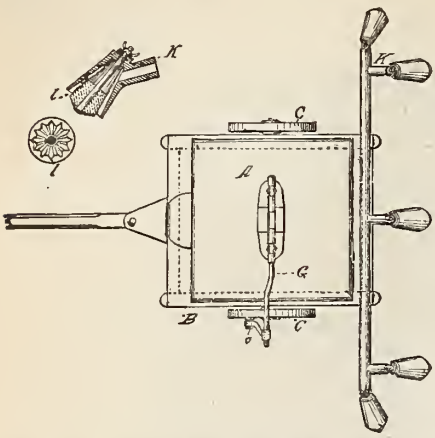


FIG. 65.—JOHNSON'S SPRAY MACHINE: top view.

The following machines produce the spray on a quite different principle and one much better calculated to prevent clogging. They are all recently invented, and by virtue of their decided advantages will, in my judgment, supersede those hitherto mentioned. They do not clog up; they distribute the spray over more rows of cotton, and they are simpler in construction and cheaper.

THE WARNER SADDLE SPRINKLER.—A device very well spoken of and advertised as the saddle sprinkler has been perfected by Mr. Jackson Warner, Austin, Tex. The liquid is contained in a bag which is used on the back of a mule or horse as a saddle, the liquid being forced out by the action of the feet. I have not been able to see either the contrivance or any specification of it.

THE BINKLEY ATOMIZER.—This sprinkler, invented but not patented by Mr. J. N. Binkley, of Columbus, Tex., and herewith illustrated, is one of the simplest and yet one of the best in use. Fig. 66, A, represents it in operation with a part of the pump. This pump is the usual double-acting force-pump secured to the top of a barrel containing the liquid. The letter *a* represents the pump cylinder, *b* the air chamber, and *c* a transverse tin pipe connected with the discharge pipe of the pump and having four of the atomizing nozzles. Fig. 66, B, shows a side view of the atomizer on a somewhat larger scale. A conical tin piece, *d*, is soldered to the pipe *c*, having at its end an orifice much larger than the fine perforations of the previous machines described. A circular tin plate, *e*, is soldered to the lower side of the cone *d*, so that the jet of water, issuing with great force from the orifice, strikes the plate at an obtuse angle

and is scattered in very fine and far reaching spray. The large orifice permits smaller objects to be thrown out with the jet, larger objects being prevented by a strainer from entering the pump, while by a slight bending of the distributing-plate, so as to bring it at more acute angles with the nozzle, the spray may be thrown more and more upward. The whole machine is very light and simple and easily made by any tinsmith at comparatively trifling cost. The principal drawback to it as

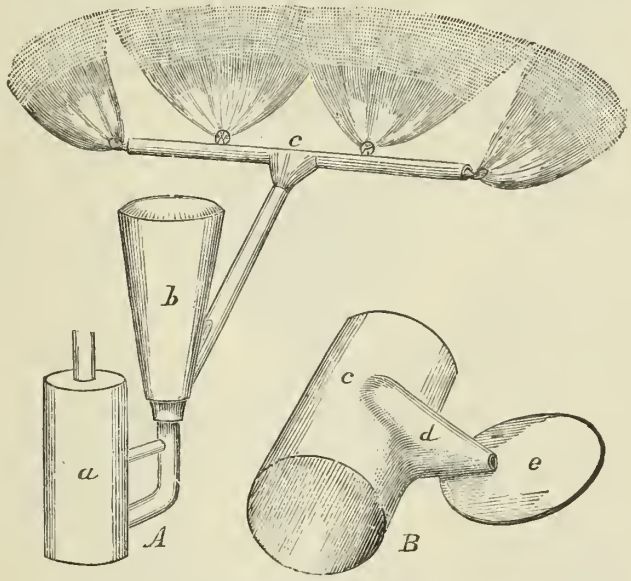


FIG. 66.—THE BINKLEY ATOMIZER.

at present constructed by Mr. Binkley is that it is made in one piece, so that in case a larger object obstructs the orifice there is some difficulty in removing the same.

This defect could be easily remedied by making the cone in two pieces, the nozzle itself to be screwed on to the basal or soldered piece. The plates and the orifices should be thoroughly cleansed and dried after use, in order to prevent rusting. The machine with four spouts, as in the figure, throws the spray over six or seven rows, but its capacity is easily increased by lengthening the transverse pipe (*c*). Its cost is less than $10.

After witnessing this machine in operation, I am satisfied that the atomizing principle is a most valuable one, and that with modified conducting pipes or tubing, so as to throw the spray from near the ground up into the plants and on the under surface of the leaves, as in Mr. Daughtrey's machine (see p. 94), it will give great satisfaction because of its cheapness and simplicity.

THE SCHIER ATOMIZER.—This atomizer was recently perfected by Mr. John Schier, of Ellingen, Tex., and is on the same general principles as the preceding. For the spraying arrangement proper a patent

was obtained October 2, 1879. In the accompanying illustration (Fig. 67) it is represented in operation, attached to a small hand-pump such as is commonly used throughout the country. The pump is to be connected by a hose with a vessel containing the liquid, and the whole machine to be operated from the rear part of a cart drawn through the field. At Fig. 68 I have given an enlarged view of the atomizer and mode of attachment, and at Fig. 69 the same with the distributing-plate disconnected, so as as to show the mode of adjustment.*

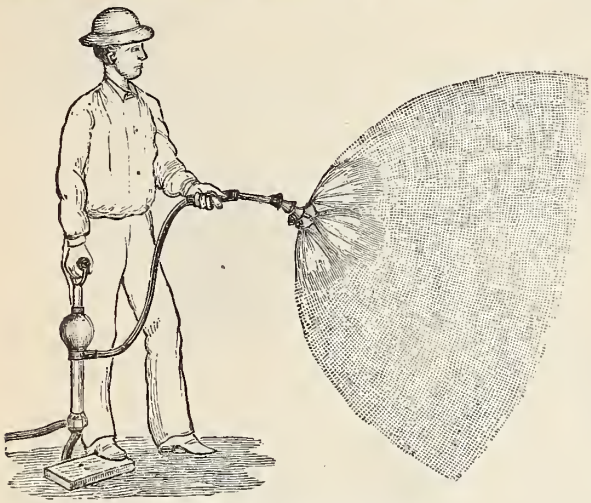


FIG. 67.—THE SCHIER ATOMIZER.

The nozzles *c c c* are connected with the conducting pipe (*a*) by means of a nut (*b*), and throw the liquid on to a distributing-plate (*d*) of brass, backed and strengthened by an outer layer of tin. This plate is secured

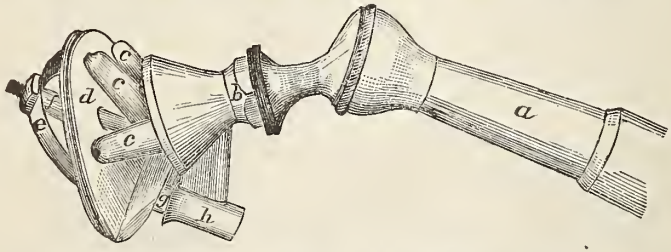


FIG. 68.—THE SCHIER ATOMIZER: nozzle and distributer connected.

in place by means of a screw soldered beneath the nozzles, running through a tube connected with and rendered firm by a bow (*e*) soldered at each end to the outer layer of the plate. The screw issuing from this tube receives a nut; while still greater security is given to the plate by a projection, *g*, beneath, which fits into a tube (*h*) attached to the nozzle-piece. The liquid, therefore, strikes the plate at an obtuse angle, but instead of one jet of liquid, as in the Binkley sprinkler, Mr. Schier brings three to bear on the same plate, the orifice of each nozzle being as large as the head of an ordinary pin. This sprinkler can be operated either as shown in

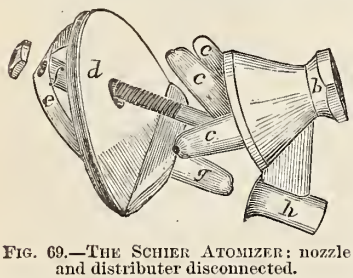


FIG. 69.—THE SCHIER ATOMIZER: nozzle and distributer disconnected.

*Mr. Schier writes that in his sprinkler, as it is patented, there is an additional arrangement for conducting back the liquid that drips from the plate.

Fig. 67 or fastened to a frame on a cart. When the distributor is held down the spray is directed upward, and it can therefore be used for spraying the under side of the leaves.

The peculiarity of this machine consists in the fact that with an exceedingly small and light instrument an efficient spray can be produced that reaches over five rows of cotton, the strength of the distributing apparatus being such as to warrant great concentration of pressure. The contrivance may be considerably simplified, and Mr. Schier, who calls his atomizer the "Diana Cotton Sprinkler," is now perfecting a machine that will supply three of these atomizers and cover sixteen rows of cotton at once, so that in one day from 150 to 200 acres may be poisoned.

RUHMANN'S IMPROVED ATOMIZER.—For his improved sprinkler, a patent of which has been applied for, Mr. Ruhmann uses the same pump and tripartite discharge-pipe already described and figured (Figs. 63 and 70*a*), and the improvement consists in an entirely new arrangement for producing the spray. In Fig. 70, which shows the improved sprinkler in operation, the letter *a* represents the discharge-pipe, *b b b* three rubber tubes (each about one foot in length, with the intermediate somewhat shorter) that connect the three arms of the discharge-pipe with the nozzles or sprinklers proper, *c c c*. One of these is represented on a larger scale in Fig. 71, and consists of a tin pipe about eight inches in length and somewhat funnel-shaped, in order to fit tightly in the rubber tube. To the anterior end of this pipe is soldered a conical nose, *a*, having an orifice of about the size of an ordinary pin-head, or large enough to prevent clogging by minute obstacles, larger ones being prevented from entering the pump by the strainer connected therewith (Fig. 61). Opposite this orifice, and almost touching it, is the point of another conical, hollow piece, *b*, with a slightly dilated or recurved rim, and held in position by a stout wire, *c*, soldered on to its edge and to the side of the tin pipe. The liquid, issuing with great force from the orifice, strikes the

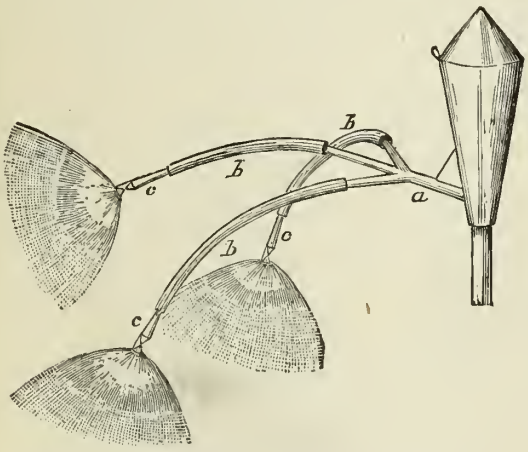


FIG. 70.—RUHMANN'S IMPROVED ATOMIZER: in operation.

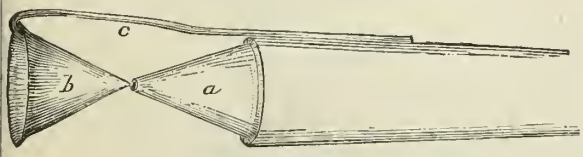


FIG. 71.—RUHMANN'S IMPROVED ATOMIZER.

point of the hollow cone, and is carried in all directions along its sides, when, by striking the bent rim, it is scattered in a bell-shaped spray.

With these three atomizers the spray may be distributed over seven rows in calm weather, and over nine rows if the wind be favorable. The price of the machine, including the pump, is $7.50. This form of sprinkler has also the advantage that it may be used to distribute the liquid from below. For this purpose the rim of the distributor should be bent back so as to form a more acute angle. Other changes necessary for this purpose have already been indicated in treating of previous machines.

There is no doubt but that these three atomizers last described are all valuable as embodying a simple principle which may be made use of at comparatively little cost, and both to throw the spray on to the plants above or up among them from below. That they have, in these respects, a decided advantage over all the other contrivances mentioned will admit of no doubt.

THE DAUGHTREY ATOMIZER.—There still remains one machine to be described in this connection which is highly interesting for several reasons: 1st, because it is the only one actually in use for the distributing of the liquid from below; 2d, because the construction of the pump is quite peculiar; and, 3d, because the arrangement for producing the spray is not only entirely different from any described in the foregoing pages, but also most simple. This machine was invented by Mr. William J. Daughtrey, of Selma, Ala. (patent No. 200376, February 19, 1878). The accompanying sketch (Fig. 72) represents it as it appears. It consists in the main of a pump, which is made self-operating by means of a pulley, and which forces air into the receiving tank and into a compression cylinder connected therewith, thus supplying the pressure necessary for the production of the spray. As will be seen from the sketch, a transverse distributing pipe is connected with a number (four in the sketch) of vertical pipes recurved at the ends, which receive the nozzles, one of which is represented in section in the accompanying Fig. 73. The nozzle N, which is screwed onto the pipe, has a closed end, n, provided with two openings, n^1, oppositely inclined, so that the jets delivered through them meet at a point near n and deflect and disperse each other so as to form an extremely fine spray. The openings n^1 are large enough to avoid being obstructed by small obstacles, and the spray produced by the two inclined jets is at once copious and powerful.

The following is a more detailed description of the machine, very much in the inventor's own words, Fig. 74 being a vertical section and Fig. 75 a detailed view of the axletree, showing the parts connected therewith in section:

In the drawings, A represents the frame of a vehicle, B B the wheels, and C C^1 the two axles constituting the axletree, which have their bearings c fastened below the frame A. Between the bearings c the axles C C′ are provided with shoulders c^1, whereby they are prevented from parting with each other longitudinally, while a socket, c^2,

at the inner end of the axle C^1 incloses the inner end of the axle C, and thereby prevents both axles from moving out of line. The two said axles may be coupled by means of a pin, c^3, inserted into the socket c^2 and axle C, but usually it is omitted, and the axles

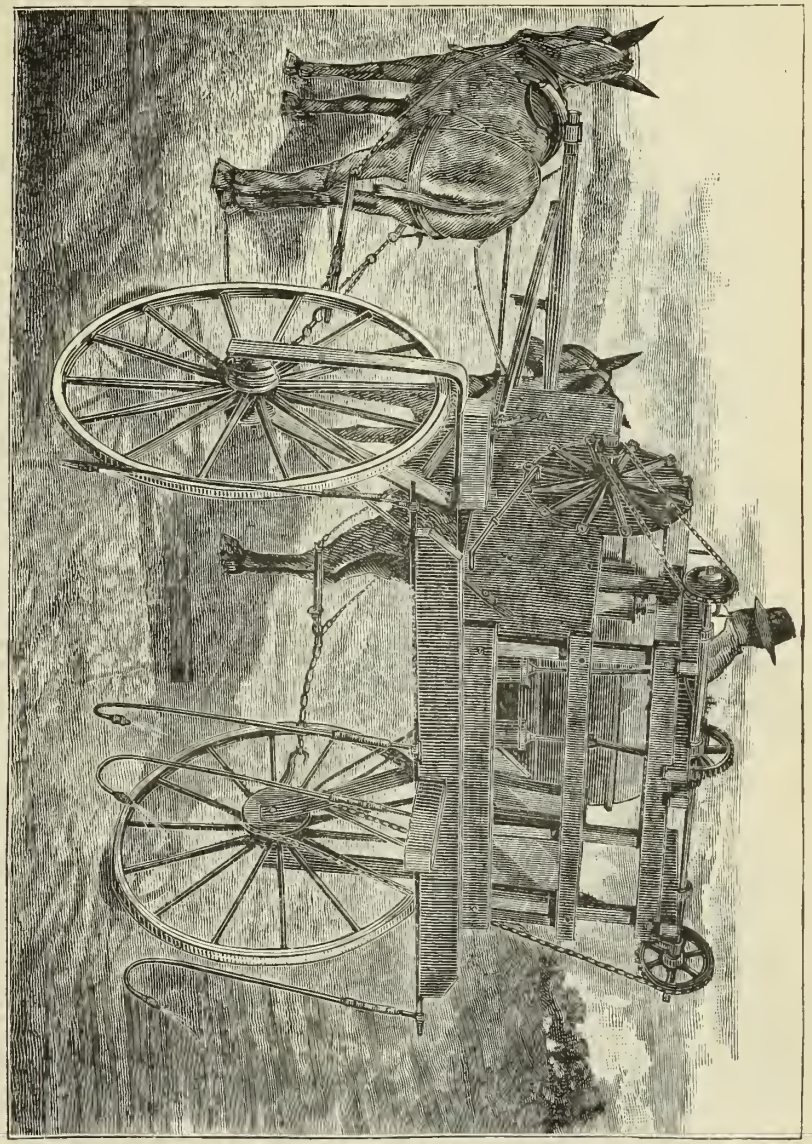


FIG. 72.—THE DAUGHTREY ATOMIZER.

C C^1 are allowed to revolve independently of each other. The hubs b of the wheels B B are provided with set-screws b^1 or coupling-pins b^2, or with both, in order to fasten them to the axles C C^1. The use of the set-screw b^1 and pin b^2 may be dispensed with to allow the wheels to run loosely on the axle, in which case a collar, C^2, is placed on either side of the hub b, with a set-screw, c^4, to keep the wheel from sliding longitudinally on its axle. The described application of the wheels B B to their axles serves to enable the operator to set

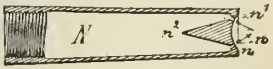


FIG. 73.

them at any distance apart required to suit the distance apart of the rows of any field to be operated upon.

The axle C is provided with a pulley, D, which, by means of a belt, drives a pulley on one end of a shaft, *e*. The shaft *e* runs in bearings e^1 fastened to the top of the frame A, and has a pulley, E^1, at the other end, which, by means of a belt, e^2, drives a pulley, F, on a shaft, *f*. The shaft *f* is secured in a central position to the ends of a barrel, G, by means of stuffing-boxes, and inside the barrel G is provided with a number of agitator-arms, f^2, for the purpose of stirring the contents of the barrel.

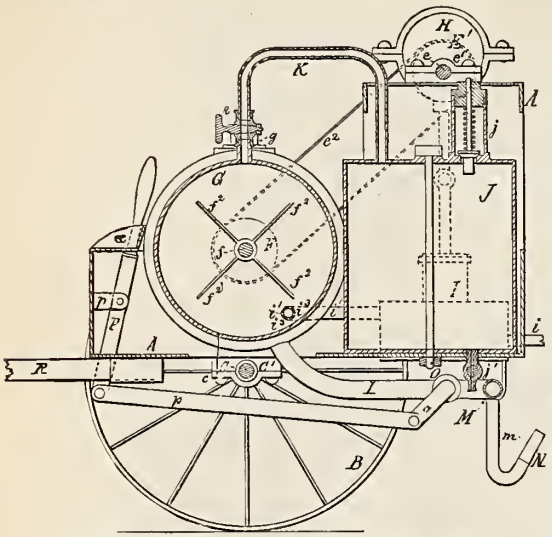


FIG. 74.—DAUGHTREY ATOMIZER: sectional view.

The shaft *e* is also provided with an eccentric, H, which operates a pump, I, of ordinary construction. The supply-pipe *i* of the pump I is adapted to have a hose attached to it when water is to be pumped. The discharge-pipe i^1 of the pump I passes through the barrel G near its bottom part, and is closed up at the end with a plug, which is removed when the pipe is to be cleared.

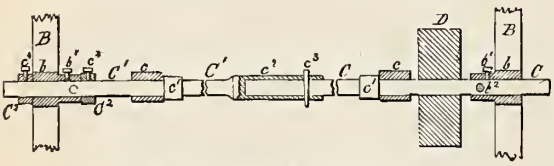


FIG. 75.—DAUGHTREY ATOMIZER: axletree.

Within the barrel G the pipe i^1 is provided with perforations, i^3, through which either air or water, as the case may be, is forced by the pump I into the barrel G. The barrel G is provided with an opening in its top part, through which its charge is supplied, and which, during the operation of the machine, is closed with a screw-plug *g*. The barrel G communicates with an air-vessel, J, by means of a pipe, K, which has a valve or cock, R, for the purpose of stopping such communication when desired.

The air-vessel J has a spring safety-valve, *j*, of common construction, which prevents the bursting of the barrel G and the vessel J, by too great a pressure of air. A cock, j^1, at the bottom of the vessel J serves to let off water accidentally deposited there.

From the bottom of the barrel G a pipe, L, conducts the charge of said barrel to a distributing-pipe, M, which is provided with a number of small pipes which are connected with the nozzles N, already described.

The operation of this machine is as follows: The barrel G is filled with the liquid either through its upper opening, or while the machine is stationary, by throwing the belts D and e^2 off the pulleys and operating the pump by turning the shaft *e* by means of crank-handles. For this purpose the pump is provided with a hose at *i* for lifting the water from a pond or well near by. When the machine is in motion the eccentric H on the shaft *e* operates the pump I, which forces air into the barrel G through the openings i^3 of the pipe i^1. In leaving the openings i^3 the air makes its way up through the water in the barrel, and produces a continuous and powerful agitation, whereby the water is thoroughly combined with its poisonous admixtures. The air is led from

the barrel G through the pipe K into the air-vessel J, from which it exerts its pressure upon the surface of the water. When a sufficient pressure is obtained the stop-cock O is opened, whereby the water is forced into the pipes L, M, and *m*, and thence through the nozzles N. If the pressure of air within the barrel G and the air-vessel J becomes too great, the surplus is let off by the safety-valve *j* into the air. At the same time the pulley e^2 moves the shaft *f* and the agitator-arms f^2, whereby the agitation of the liquid by the air forced through the openings i^3 is increased in force.

The inventor of this machine, who is a practical machinist, has probably given more time to it than has been given to any of those described in this bulletin, his object being at once to accomplish the desired end of throwing a fine spray from below, to pass over tall cotton without injuring it and to save labor. The great objection to the machine is its complication, expensiveness, and weight. It differs from the Johnson machine in that the wheels are so widely separated that they include two rows of cotton, and the whole machine is so elevated that the tongue is on a level with the backs of the animals which draw it, and the cross-tree is connected to a peculiar saddle, so that the whole weight of the machine falls upon the back. In practice this is found to be very galling to the animals, and various modifications have already suggested themselves to the inventor. There is little hope of this machine coming into use until Mr. Daughtrey succeeds in materially reducing its weight and cost, notwithstanding the excellence of many of its features.

Machines for applying Vapors.

Several years before mineral poisons came into use against the Cotton Worm two machines were invented and patented for the wholesale destruction of the insect. They are of interest here as illustrating the first attempts made to destroy the pest by machinery. One of them is more particularly worthy of mention, as it aims to apply one of the deadliest materials against insect life known, viz., oil, and this in the shape of vapor. The other is intended to apply sulphur vapor. Whether these machines were ever in use or whether they ever did any effective work is extremely doubtful, but it is certain that they are to-day superseded by the atomizers already described. The accompanying descriptions of them have, therefore, historical rather than a practical value.

THE STEINMANN VAPORIZER.—This was invented by Mr. Charles Steinmann, of Napoleonville, La. (patent No. 74165, February 4, 1868). Its character may be thus briefly given: Steam is raised by a transportable steam-boiler and issues from a series of jet-pipes or nipples. At the same time some cheap oil, as kerosene, lard, or cotton-seed oil, is made to drip from a reservoir over the orifices from which the steam escapes. The oil is thus vaporized and envelops the rows of plants between which the machine is to be drawn. The inventor claims that the vapor kills the worms without injuring the plant, and that one application will protect the field for the rest of the season, and that his invention "upon its general use will finally exterminate every tribe of insect,"

&c. It is hardly necessary to say that the two latter claims are utopian and extravagant.

The following is a description of this machine in the inventor's own words; the Fig. 76 being a side elevation, and Fig. 77 a rear end view of the machine:

A represents the receiver or reservoir to contain the oil, and B a funnel for supplying the boiler with water, and which connects directly with a heater, E, that is placed on top of the boiler, instead of with the boiler proper, in which heater a supply of water is always kept, to be heated by the radiation of heat from that part of the boiler or shell of the boiler on which it rests. The interior of the heater is connected with the interior of the boiler F by two pipes, H and O, which are each provided with a stop-cock. By this mode of connection, the water in the heater can be retained or driven into the boiler at pleasure, it being only necessary to keep the cocks closed to retain it, or to open them to force the water into the boiler. The latter result is accomplished by the pressure of the steam through pipe H, the water going into the boiler through pipe O. Whenever the water is thrown out of the heater into the boiler, the former should be refilled through the funnel B, the stop-cock, in the short pipe R to which it is attached, being opened to allow the water to enter. On top of the boiler, at some point between its rear end and the heater E, a perpendicular pipe, C, is inserted into it, which pipe should be long enough to carry its upper end to a height somewhat above the tallest cotton-plants. The pipe C is provided with a stop-cock, D, and connects at its upper extremity with a cross pipe, M, of the form as shown at Fig. 77, and to approach very near the ground at both its ends. In that portion of the pipe M that is horizontal are two stop-cocks, one upon either side of the point of connection with pipe C, which serve the purpose of stopping the issue of steam either entirely, or upon one side only of the machine. At a point near and below the flexures or elbows of the pipe M at which it turns towards the ground, on both sides of the machine, and from this point down to the two extremities of the said pipe, at short intervals, are inserted small short pipes *a*, which, diminishing in size to their extremities, where they come very nearly to a point, serve as vents or jets for the escaping steam when the machine is in operation. Placed alongside the pipe M, in front of it, and in contact with it everywhere, excepting only for a little space near its top part, where it bends forward, as shown at Fig. 76, is another pipe, K, exactly corresponding with pipe M in size and shape, and provided with the same number of precisely similar jet-pipes, *a*, that are so placed as to be exactly over the corresponding jets in pipe M, that is to say, at their extremities, and in the closest possible contact therewith. The object of this is to insure the dripping of the oil over the orifices from which the steam escapes. Over the center of the upper

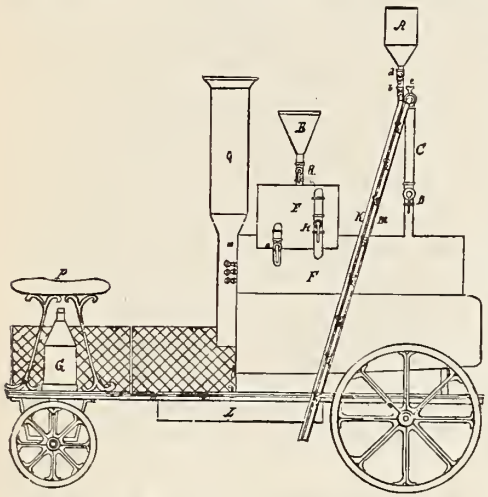


FIG. 76.—THE STEINMANN VAPORIZER: side elevation.

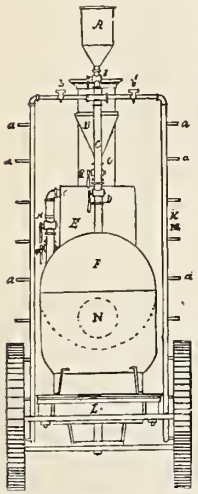


Fig. 77.—THE STEINMANN VAPORIZER: rear view.

and horizontal section of pipe K, and connecting therewith by a short pipe, *d*, is placed the reservoir A for oil. Stop-cocks in the pipe K, near to and upon each side of the pipe *d*, prevent a flow of oil down either end of said pipe K, or permit it to flow into both or only one end, as occasion may require, at the pleasure of the operator. A platform in front of the boiler or furnace is provided on which a supply of fuel may be carried, a light railing or lattice-guard on the sides of the platform protecting it. A driver's seat, P, is placed on this platform under which a vessel of oil may be carried, as well as other things needed in the operation of the machine. This invention may be of any dimensions, to be drawn by one or more horses.

THE PERL VAPOR-GENERATOR.—This was invented by Dr. M. Perl, of Houston, Tex. (patent No. 91365, June 15, 1869), for the purpose of destroying the worms by means of sulphur vapor, and consists, in the main, of a gas-generator, which is placed on a cart, intended to be drawn between two rows of cotton, and provided with a fire-box and a pair of bellows, which are worked by means of a pulley.

The accompanying diagrams (Fig. 78) represent this machine, the upper figure being a vertical section and the lower a side elevation.

Upon the wagon A is placed the gas-generator B, consisting of a fire-box, *c*, separated from the lower part of the generator by a concavo-convex bottom *c'*.

To the upper chamber D of the generator is attached one end of the blower or bellows E. This bellows is provided with a shaft, *d*, upon which are secured metal wings, *d'*.

On one end of the shaft *d* is attached the cog-wheel *e*, gearing into the cog-wheel *e'*, secured to the wagon-wheel G. The other end of the shaft is provided with a crank, *f*, which is attached to upper end of pitman *i*, the lower end of this pitman being attached to the pedal *h*, secured to pendants *h' h'*, attached to the under side of the axle-tree H. G'' is a hose, with a perforated nozzle, *m*, and stop-cock, *n*, which is attached to the top of the gas-generator. M is the chimney.

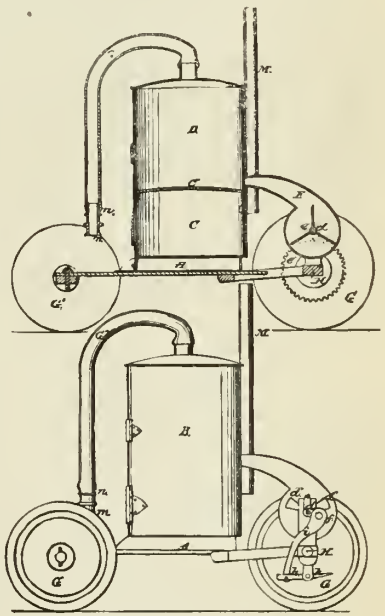


FIG. 78.—THE PERL VAPOR-GENERATOR.

The machine can be operated, when in motion or stationary, in the following manner:

A fire is made in the fire-box *c*, and a certain quantity of sulphur is placed in the gas-generator B, in order to form sulphureous gas. The blower E is set in operation, when in motion, by the cog-wheels *e e'*, and when stationary, by detaching the cog-wheel *e'*, and attaching it to the crank *f*.

The action of the blower or bellows will not only furnish sufficient air in forming sulphureous gas, but it will also force the gas through the hose to any desired point.

Aside of the circumstance that only two rows of cotton are supplied at once with vapor, it is very doubtful whether the worms are killed by sulphur vapor in the open air, judging from its effects on other insects when not confined.

Finally, in this connection it is well to state that Mr. Charles T. Hurd, of Victoria, Tex., whose machine for dusting has already been described

(p. 76), suggests that with some slight changes it can be converted into a vaporizer, so as to throw a jet of poisonous vapor on the plants.

DESTRUCTION OF THE MOTH.

Easy as it may seem to prevent the mischief done by the worms by trapping or otherwise killing the parent moths, and notwithstanding the fact that one method of attracting them has been known and used for very many years, and that another method of doing so has been more recently discovered, yet the results that have followed the attempts to destroy or exterminate the moths by these methods are not, as a rule, encouraging. The unsatisfactory results may be attributed to, *first*, lack of concerted action; and, *second*, delayed attempts to kill when the moths had already become too numerous and the worms had done considerable damage.

It has already been remarked, with regard to the first point, that concerted action over the whole cotton-growing country cannot be expected; but if the planters in those more or less limited districts that are known as the distributing centers of the insect, or even in those particular spots where the worms appear and reappear year after year, would make earnest effort, at the right time, to trap and kill the moths, there is little doubt but that the excessive increase of the insect would be either retarded or prevented. If this pest is suffered to increase until the third or fourth generation, any attempt to lessen the number of worms by killing the moths will necessarily prove futile. To make this method of preventing injury of any avail, action must be taken *early* in the season.

Lamps for attracting the Moth.

That the moth is attracted by light is an old and well-known fact, and in the days of slavery the only remedy generally used by planters, besides the hand-picking of the worms, was to light large fires in, or have burning torches carried through, the fields at night. It is impossible to say at the present time whether or not these efforts were successful, but it remains a certainty that in "worm years" the progress of the ravages has never been prevented by such means. It is almost needless to remark that in those days, as in the present, such means were generally resorted to when the moths had become quite numerous, and when, therefore, no success could be expected.

Special fires intended for this purpose were generally made of dry wood placed upon earth elevated on platforms. While for the reasons here given I have little faith in the utility of such means at any other season than early spring, yet the practice of cleaning the fields of all rubbish and old stalks by making large bonfires in winter—a practice that prevailed before the war, but which has been largely abandoned since—is greatly to be commended on general grounds.

It has been found troublesome, and, in some parts of the country even

expensive, to keep up large fires during the whole or greater part of the night; and during the last decade a great many lamps have been invented to take the place of fires. A lamp is more effective in attracting the moths than is a large open fire; for the heat and smoke of the latter scare away great numbers. Where lamps are employed there must be connected with them devices to kill the moths that are attracted by the light, and such killing is best accomplished by placing the lamps in pans filled with various substances of a sticky or destructive nature.

During the earlier part of last summer extensive experiments were made by Mr. Schwarz to test the efficacy of lamps. Though it was already too late in the season to check the increase of the insect, some of the results are not without interest. The number of moths nightly killed by a single lamp varied very much according to its location, but averaged not more than six specimens in the latter part of June, the number increasing rapidly during the next month. It was also found that these lamps attract and kill an immense number of other insects. Among these are many injurious insects, as *Heliothis armigera* (the parent of the Boll Worm), which, by the way, appears to be more readily attracted than the Cotton Moth, and several species of May-beetles (*Lachnosterna*) and others; but also, unfortunately, large numbers of the natural enemies of the Cotton Worm, as the nocturnal Tiger-beetles, Ground-beetles, and some of the *Heteroptera* already mentioned. It becomes questionable, therefore, whether the lamps are not more productive of harm than good, especially at times when the moths are numerous. However, if, as is doubtless the case, the hibernating moths fly about early in the spring, then this will be the best time to use lamps in places where the moths have been seen flying, as in the vicinity of gin-houses, &c. In the month of March and in the earlier part of April they should be placed at such spots in the fields where the first worms had been observed in previous years.

Experiments made under my direction have proved that during moonlight nights fires or lamps have but little attraction for the moths, and, further, that better results are obtained before than after midnight.

The only instance with which I am familiar where lamps (those made by Colonel Lewis and hereafter described) have been used on a sufficiently large scale to fully test their efficacy, is that around Hearne, Tex., in 1878. Over 1,000 lamps were used in that vicinity during a period of several weeks, and while it was true that cotton was not injured that year, the same was equally true throughout that whole section of the country; so that it was impossible to draw any satisfactory conclusions. Still, where they were used pretty extensively the present year they did not prevent final injury to the cotton, and where but a few are used in some particular fields, it is undoubtedly true, and in accordance with general experience, that more harm than good ensues to the individual using them—the moths being allured from other fields and frequently laying their eggs before perishing. The worms are, consequently, often more numerous at such centers than elsewhere.

The following enumeration of lamps for attracting and killing the moth is by no means a complete one. Some of the inventions are no longer used, and descriptions or samples of them unattainable; others are mere copies of such as are here described, and are therefore omitted; while still others are too complicated and expensive to warrant mention. A few words have still to be said concerning the mixture to be used, in connection with the lamps, for killing the moth. Almost any sticky substance, such as paint, tar, molasses, soap-suds, &c., will answer the purpose; but the cheapest and most effective means is to half fill the pan with water, and then pour in about a table-spoonful of kerosene. The mixture can be strained off in the morning and used again.

FIG. 79.—THE GARRETT LAMP.

The lamps may be divided into two classes—those which are to be kept stationary, and those which are to be drawn or carried through the fields.

THE GARRETT LAMP.—This was invented by Mr. James G. G. Garrett, of Port Gibson, Miss., in November, 1872. The accompanying Fig. 79 is a side view, partly in section, of the same. The letter A represents a stake driven into the ground, with a plank (B) nailed to the upper end. Upon this point is placed a sheet-iron pan (C) about 18 inches wide and 2 inches deep. In the center of the pan is a block or support (D) about two inches high, upon which is set an ordinary lantern (E), which is kept in place by being secured to the edges of the plank (B) by two or more cords (F). Into the pan (C) some coal-tar or molasses, or other suitable material, is poured so as to a little more than cover the bottom thereof.

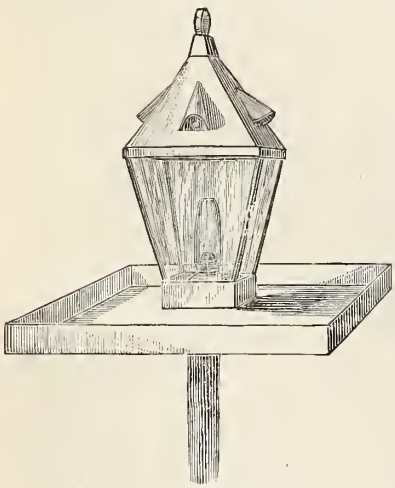


FIG. 80.—THE BINKLEY LAMP.

THE BINKLEY LAMP.—Mr. J. N. Binkley, of Columbus, Tex., uses a lamp which I herewith illustrate (Fig. 80). It is essentially the same as the foregoing, and consists, like Garrett's lamp, of a tin plate which may be rectangular or round, and which is placed on a board, nailed to the upper end of a stake or pole. A lantern of the form shown in the figure is soldered to the centre of the plate, the cover of which lantern has openings to aid ventilation, and may, when necessary, be removed. A common kerosene lamp, with or without chimney, is placed in the lantern, and the pan is half-filled with water and a little kerosene on top, or with soap-suds, or molasses, &c.

A similar but still simpler lamp, first made by Col. Charles Lewis, of Hearne, Tex., has for some time been in use in the fields in the Brazos River bottom. It consists of the usual shallow tin plate placed upon a board that is nailed to the upper end of a stake or post. In the middle of this pan is placed a common kerosene lantern, large enough to burn the whole night, or at least the larger part thereof. In 1878 the planters near Hearne, Tex., were nightly burning over 1,000 of these lamps during a period of several weeks. The cost of this lamp, with the tin pan, is between 30 and 40 cents, and the cost of burning it one night about one cent. One lamp is generally used for every five acres where the land is level, but at shorter intervals where it is rolling.

The McQueen Lamp.—This again does not materially differ from the others so far mentioned. Patented by Mr. B. F. McQueen, of Manack, Ala. (No. 166124, July 27, 1875), it consists of an ordinary lantern which is secured to the center of a shallow basin, beneath which is fastened a tube intended to fit on a post or stake. At the top of the lantern is a horizontal screen of tin, forming a reflector and serving also to precipitate the insects in the pan below.

The Rigel Lamp.—Invented and patented by Mr. Mark Rigel, of Ala. (patent dated January 28, 1873), this lamp differs only in being made so as to hang by a ring, and in the lantern having, in addition to a horizontal reflector, several vertical ones.

There is another class of lamps of a still simpler nature, consisting of a torch-light, large enough to prevent its being extinguished by the wind, and placed in the middle of a tin pan. While cheaper than those with a steady light they are decidedly less effective, and, moreover, they consume more oil. The simplest lamp of this class is a stout bottle filled with kerosene and mounted with a wick.

The Walker Lamp.—This has been constructed by Mr. John E. Walker, of Winchester, Tex., and is represented herewith (Fig. 81). It consists of the usual tin pan placed on a post, and of a short, funnel-shaped pipe soldered to its center. A second hollow tube of the same shape, inverted, is attached to the bottom of the oil-reservoir so as to fit firmly over the first. The reservoir has at the top a raised mouth, with a worm, through which the oil is poured and on to which the wick-tube is screwed as in the figure, the lower part of the tube which enters the reservoir being perforated. The shoulder above the screw is designed to prevent the falling of cinders or fire into the kerosene.

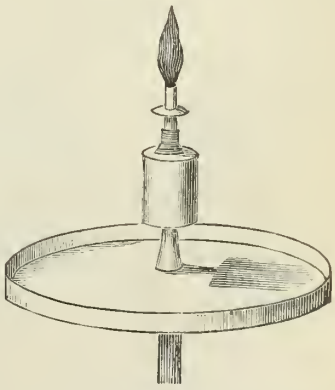


Fig. 81.—The Walker Lamp.

One of the simplest lamps is that which I herewith illustrate (Fig. 82). It has been extensively used and is a mere modification and simplification of the Walker lamp. The reservoir is here soldered to the center of the pan, and the wick-tube to the top of the oil-reservoir. The oil is poured in through an opening near the edge of the top of the reservoir.

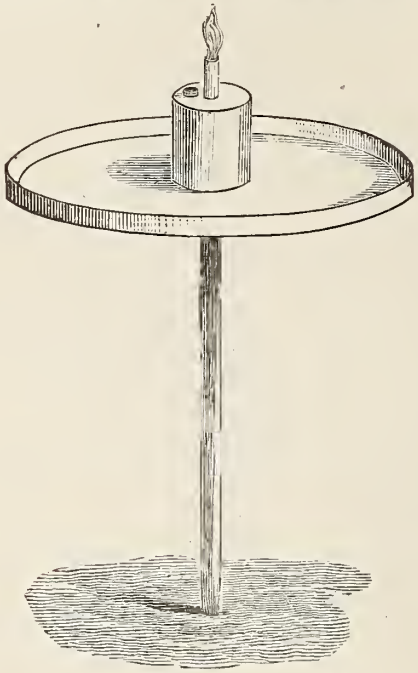


Fig. 82.—Simple form of Lamp.

The Pugh Lamp.—Another somewhat more complicated contrivance of this class is that invented by Mr. Edward D. Pugh, of Fort Plain, Iowa (patent No. 130390, August 13, 1872). Fig. 83 shows that it consists of the usual shallow pan A, wherein is placed a rectangular case, B, made of glass and sheet-iron, with short feet attached to its bottom and with a cover, *c*. The bottom is perforated for ventilation, and a lamp, D, is placed within the case. So far there is nothing particular about this lamp, but it has, in addition, an arrangement to increase its attractiveness to the moths. Around the case is a frame, *a a*, with tubes, *b b*, attached to the inside and aperture communicating with the outside. E represents a common, long-necked bottle placed on one of the tubes *b*,

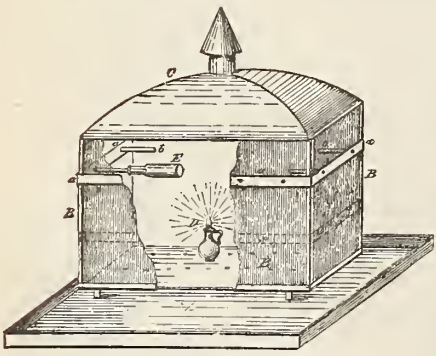


Fig. 83.—The Pugh Lamp.

on the inside of the case. The number of the frames and of the tubes may vary, but on each of them a bottle is placed containing honey and wax, or other suitable bait that is attractive to moths, which are consequently not only attracted by the light, but by the smell of the baits, and are either killed by falling in the pan or by passing through the apertures into the bottles, from which they cannot escape.

LAMPS IN MOTION.—As a result of the observation that the moths that are flying in the field are not so readily attracted by a stationary light as by one in motion, the two following machines have been invented with a view of being drawn or dragged through the field: The first of these is the LE BLANC COTTON-MOTH DESTROYER, invented by Mr. Auguste Le Blanc, of Louisiana, La. (patent No. 101028, March 22, 1870), and represented at Fig. 84. The apparatus is mounted on wheels (A) and consists of a platform (B), to which are secured a number of extensible posts (*c*) supporting a roof (D), from which is suspended by a chain or rope the devices to obtain the light. This device consists of the reservoir (E), which communicates through pipes (*a* and *b*) with a series of radial burners (F), which are arranged so as to form a circle of about eight feet in circumference, though the dimensions may be increased or decreased. The posts (*c*) are rendered extensible by being formed in two parts (*c d*), the one fitting and sliding in the other. A series of holes (*e*) are made, one in the part (*c*), while a spring stop or pin (*f*) is fixed to the other (*d*). By this means the burners may be raised or lowered at pleasure. The roof does not serve alone to shield the burners from rain, but, if painted with a white paint or with any other sticky substance, also helps to attract and destroy the moths. In order to use this machine effectually, Mr. Le Blanc suggests that the cotton should be planted so as to leave at intervals, say, of two acres, a space wide enough between the rows to permit the machine to pass through.

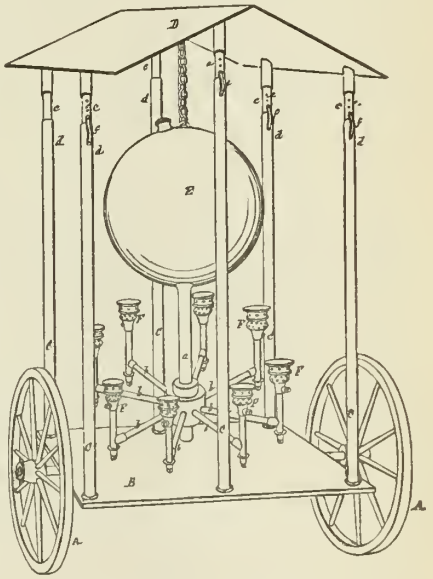


FIG. 84.—LE BLANC'S COTTON-MOTH DESTROYER.

The second machine to be mentioned in this connection is the FORDTRAN COTTON-MOTH DESTROYER, invented by Mr. E. H. Fordtran, of Flatonia, Tex. (patent No. 196211, October 16, 1877). It consists of two S-shaped runners very much like those of a common sleigh, and which are made of bent gas-pipes. They are connected with each other at their upper end by a cross-beam, to which is attached a tongue for draw-

ing purposes. Another gas-pipe between these runners is so fastened to them that it can be lowered or raised, according to the height of the plants, by sliding along the runners; and on this pipe are several movable rings which can be firmly secured to the pipe by means of a screw. These rings support each a round shallow tin pan, which, by means of the movable rings, may always be held in a horizontal position. In the middle of each of these pans (the number of which may vary) is secured a common kerosene lantern. The apparatus, which is large enough to reach over three rows of cotton, is drawn over the field at night time. It is on runners and not on wheels, because the former do not injure the cotton.

These movable lamps are doubtless very effective, and if used extensively and at the right time would be of good service. Aside from the unsatisfactory results of lamps generally, these have an additional disadvantage in that they must be worked at night.

Poisoned Sweets and Fluids as Means of destroying the Moths.

It has long been known that the Cotton Moth, like most of the other species of its family, has a great fondness for sweets. Southern writers upon the insect repeatedly mention the fact that the moth is numerously attracted by barrels or other vessels containing molasses, by sugar-vats, &c.; while, as we have already seen (p. 15), it is very fond of most ripe fruits. The second peach-crop very often suffers materially from the attacks of these moths, as, by means of the spinous tip of their tongue, they literally work through the skin, suck out the juices, and excavate large holes. Figs and melons are often injured in the same way; indeed, it is almost impossible to raise some of the finer varieties of figs if these moths are abundant.

There was some hope of beneficial results being obtained by using baits that would prove at the same time attractive and destructive to the moths, since, if we kill the parents, we prevent the injury of their progeny. Taking advantage of the fondness of the moths for sweet substances, many planters have been in the habit of breaking open ripe watermelons, sprinkling them with Paris green or arsenic, and depositing them in cotton fields. Very good results have followed, so far as the destruction of the moths is concerned; and it is a little surprising, viewed at from the preconceived notions of entomologists, that comparatively coarse substances like these minerals should be sucked up through the proboscis.

A number of experiments, with a view of testing the most attractive as well as the most deadly substances, have been made in various parts of the cotton belt during the past two years under my direction. Ripe peaches dusted with arsenic or drenched with a solution of arsenic, dried peaches moistened with water and poisoned in the same way, were placed in boxes on the ground in the fields. On examining the boxes the next morning, several dead moths were found in those containing

the fresh peaches, but none in those with the dried ones. Experiments with a mixture of molasses and rum, or vinegar, or beer, poisoned with a small quantity of arsenic, Paris green, London purple, or cyanide of potassium, and smeared onto the trunks of trees, or onto fence poles near cotton fields, or again onto the leaves of the plants, also proved that a number of moths may be killed in this way, though it is difficult, if not impossible, to get at the exact number, since many fly away before dying. The mixture of molasses and beer seems to have the greatest attractiveness, and the virtue of all these mixtures for this purpose may be enhanced by the addition of the essence or flavoring extracts of certain fruits, as peaches and apples. None of these mixtures are as attractive, however, as the fruits themselves, or even as watermelons.

The liquids may be employed not only by smearing in the manner set forth, but also in shallow tin pans or vessels placed in the fields upon pedestals, as in the case of the lamps already described. Where such pans or other vessels are used there should be a wooden lattice-work made to float on the liquid, so that the moths may reach it without drowning, and thus be able to get away to perish elsewhere and make room for others. These liquids are frequently used in wide-mouthed bottles distributed over the fields. One general rule, already laid down in treating of the use of lamps, should be observed in the employment of these liquids and poisons. It is that they be placed in the field only about sunset, and not allowed to remain during the day; otherwise, more beneficial than injurious insects are actually allured. The smearing has the advantage over the use in pans and bottles, in that fewer beneficial insects are destroyed.

I cannot say that these experiments have led me to be in any way sanguine of substantial benefit flowing from this mode of killing the moths in the autumn, which is the season when they are most easily so destroyed; for they do not seem to care much for such baits except when they cannot get their more natural food, in the shape of saccharine exudations. The fact that early or summer ripening peaches are not injured—a fact that is well attested by many correspondents—also indicates that the moths do not care so much for fruits even, so long as they can obtain nourishment in the cotton fields and so long as they are not congregating in numbers.

Experiments made in the summer season with these artificial baits indicate that a much smaller percentage of moths is allured thereto, and while there can be no question of our ability to kill a certain number in this manner, it would prove a most expensive remedy if used on a sufficiently large scale to materially reduce their numbers. In fact, I have become convinced that there is very little use in attempting to destroy the parent moth in the latter part of the season. In discussing the question of hibernation, it has been made pretty clear that the great bulk of these are naturally destined to perish in any event, so that the labor is largely thrown away.

Until, therefore, we discover some baits that shall have a greater attraction for the moths than the natural sweets they feed upon, there is little to expect from this mode of warfare. There is a season, however, when the use of these baits is strongly to be recommended, and, oddly enough, it is the season when nobody thinks of using them. It is in this as it is with the lamps; the greatest good will result from attracting and destroying the first moths in spring after they issue from their winter quarters. Every female killed at that season is equivalent to the destruction of several hundred worms later in the season, whereas not one in a thousand, and perhaps not one in a hundred thousand, of the moths killed in autumn would, in the natural course of events, have survived to beget progeny. Concerted action is just as necessary here as in the use of lamps.

The recommendation to use white rags in the field has frequently been made in the Southern papers, on the supposition that the female moth is attracted to such rags and will lay her eggs thereon. I know not how this idea originated, but so far as I am able to learn it is one of the many fallacies that have prevailed regarding the habits of the insect.

Finally, in this connection, I would mention a theory or proposed remedy by Dr. J. L. Lupton, of Frederick County, Virginia. Noticing that the Bee-moth was more attracted to a fluid sweetened and flavored from the hive than to any other kind, he conceived the idea that the Cotton moth would also be most attracted by sweetened water which was flavored with the bruised leaves of the cotton plant. Prof. N. T. Lupton, of Vanderbilt University, Nashville, made an experiment in 1872 which seemed to indicate that the liquid thus prepared with cotton leaves had the greater attractiveness for the moth as compared with ordinary molasses and water; but it is doubtful whether it would compare as favorably with some of the other mixtures already alluded to.

APPENDIX.

[As a sequence to the Bulletin proper, and as illustrating the conflicting views and theories held by the more intelligent correspondents, I add a few of the reports received in response to the circular printed in the Introduction. The replies are numbered to correspond with the questions, and it is hardly necessary to inform the reader who has perused the Bulletin proper that the views and theories of the different writers are not necessarily indorsed, because they are printed just as they were received, and without comment.]

SAINT FRANCISVILLE, WEST FELICIANA PARISH, LOUISIANA,
October 2, 1879.

A circular from you requesting answers to certain questions relative to the Cotton Worm was received some months since, and my reply has been deferred to this date in order to enable me to observe the worm and its depredations throughout the entire season. Last year a similar circular was received from the office of the Agricultural Department, to which I replied fully and specially to all the questions as far as my information extended.

1. Cotton has been grown here since this century began—eighty years—and perhaps longer. I am a native, fifty-eight years old, and my family and relatives came here from North Carolina in Spanish times and soon afterwards, *i. e.*, from 1800 to 1810. They always raised cotton from their first settlement here.

2. I have no records or histories to refer to in order to answer this question fully and accurately. From old settlers I have heard that the Army Worm came here before my recollection—this is, before 1827 or 1828—and destroyed the crops. I think this was between 1820 and 1824. I have heard old settlers who came here from South Carolina say that the Cotton Worm came there before 1815, and ravaged the crops. From my recollection, the worms never appeared here in any great numbers after 1828 until 1840 or 1841. I was raised on a plantation, where I now live, my father and all of my family on my father's and mother's side being large cotton planters, and my recollection dates back to 1828 about all matters of any great moment.

In the above year, 1840 or 1841, I returned home on a visit from school late in the fall, say October, and found the cotton fields white with the open cotton and filled also with Cotton Worms. In a few days they ate all the leaves from the stalks of cotton, and then began to crawl off, moving like a great army, and filling the ruts and washes in the roads and fields with millions of worms, which being unable to crawl out died there in masses. As the worms appeared that year quite late in the season, no damage was done to the cotton crop, except to make the open cotton dirty and trashy from the excrements and cut leaves dropped by the worms on the cotton.

In 1846 the worms appeared again, and that year the crops were greatly injured, the worms eating the cotton up so early in the season that not more than 50 to 70 per cent. of a full crop was made by planters in this section. The worms never came again in sufficient numbers to attract any general notice until after the war began. We heard of their appearance soon after the Federal occupation of New Orleans and the lower part of the State, from the great desire to get cotton to supply the markets and factories abroad and at the North and the many attempts made in that region to raise cotton for that purpose. Inside of the Confederate lines, in this section, very

little cotton was raised during the war, the people turning their attention almost exclusively to raising food crops. Worms appeared, however, in the small fields of cotton raised here for several years before the war ended. Beginning with 1866, they have been in this section every year since, sometimes many and again very few; but no year has passed with an *entire* absence of the worm since 1866.

3. I do not think the coldness or mildness of the winters affects the worms here—our winters are never very cold—as our latitude is too far South to permit it. We have had very cold weather, for this section, many times since 1866, and the worms have appeared every year, more or less.

4. They are always worse in wet summers; never very bad in very hot, dry summers. They are generally noticed first in July, and if its after progress is attended by repeated rains during July, August, and September, the crops are very apt to be much injured, if not completely demolished. But if it remains hot and dry during the above-named months, the worms never do much damage.

5. Of my own knowledge, they are to be seen here first in June or July, but some of my friends and neighbors have reported seeing them occasionally in May, in few numbers.

6. They are almost always found first on the same places and same plantations, scattered over the country, without any apparent regard to character of soil or surrounding circumstances. This fact has been generally noticed and spoken of, but no solution has been made of it that is satisfactory and reasonable. Like most other questions among men, outside of mathematics, discussion never satisfies all parties nor settles the question.

7. I have no experience at all of the winter habits of the insect, but I am satisfied it remains here during the winter, in some form, and does not come here regularly or at intervals from any distance. My reasons for thinking so are too numerous to attempt to write them to you, unless I thought I could prove the fact to a demonstration, and thus settle the matter beyond all future question or dispute.

8. Birds of many kinds prey upon the worms, and many insects prey on both the worm at all ages and stages of its growth and also feed on or destroy the eggs. No quadrupeds disturb either eggs or worms, to my knowledge. Ants of various sorts prey on them—both eggs and small worms. I have heard many insects spoken of, by persons who had given the matter close attention, as being enemies to the Cotton Worms, and preying on or destroying the eggs, young worms, and also those fully grown. I cannot speak on these points from personal knowledge, not being a scientist nor professional man, and having no turn of thought in that direction. I am satisfied that many animals and insects prey on and destroy the Cotton Worm's eggs, young, and grown worms, or they would eat up the cotton every year they appear here. They increase by nature so very rapidly after their first appearance that, unless they met many and destructive enemies besides man, they would always increase in numbers so great as to destroy the crop annually. In wet years these various enemies are not present themselves in sufficient numbers to make any impression on the Cotton Worm, but in dry seasons they are numerous enough to nearly annihilate the Cotton Worm, and thus prevent any great damage to the cotton crop.

9. I have no experience about destroying the Cotton Moth. Many might, no doubt, be destroyed by lamps, fires, &c., but the whole planting population would have to engage in it systematically and persistently, or it would amount to nothing. The destruction of any number of moths by a few planters or neighborhoods would do no good. I have never heard of sugar, molasses, or anything of the sort being tried to lure the moths. I think all such things humbugs, and on a par with the Yankee plan tried in Lower Louisiana during the war, *i. e.*, to spread tar around the cotton-fields to prevent the Cotton Worms from entering them.

10. I have no experience to enable me to reply to this question.

11. I cannot afford any information on this question.

12. I have never seen jute nor any other plant being tried in this section for any such purpose. Have heard stories told of such things being tried elsewhere.

13. Paris green, Texas Worm Destroyer, and such poisonous medicine are the only things which have ever been used here to destroy the worms. I have seen Paris green tried many times, and heard of its trial for years. There is no doubt that it will destroy the Cotton Worm and preserve the cotton plants, when the preparation is genuine and not a cheat and it is used properly and thoroughly. Like everything else done in this world, it must be done properly, thoroughly, and persistently to succeed. I have no personal knowledge of the Texas Worm Destroyer, but it is very highly recommended, indeed.

14. I have never known any injury to happen to man, beast, or plant here from using Paris green. All know that it is a violent poison, and use it with caution. No doubt, man, animals, and plants can be injured by it, and perhaps all have been injured in some places by its incautious use.

15. Paris green used in liquid form, from large tin watering-pots made specially for the purpose, has been most successful here; it is the preparation generally used.

16. I cannot state the cost of using Paris green per acre, but its cost is not great, and does not enter into any man's calculation when he sets about to kill the Army Worm. I have seen a field of cotton saved by two applications of it, which were made at intervals of a month apart. This field yielded one bale per acre, whereas without the destruction of the worms it would not have made half a bale per acre. These worm-poisons are now made and sold in great quantities by responsible parties, and, like all other articles of general commerce, are abundant and cheap. There is no question but that the cotton crop can be saved in part, if not in whole, from any future destruction by the Cotton Worms, in all sections where the planters are energetic, intelligent, and harmonious in action by the use of poisons—Paris green, Texas Worm Killer, arsenic in some form, or some other poison. I cannot now say that any plan can be proposed to destroy the worm or moth before its appearance in the cotton fields. Fires, lamps, &c., would kill immense numbers of moths, but would only retain the worms, and not destroy them.

I hope what I have written above may prove acceptable to you. I have given you all the information I could which I could vouch for personally. Any future communication from you or your office will be replied to fully and candidly.

The Cotton Worms have made their annual appearance in our parish this year, but have done no general damage. Some few fields have suffered, on alluvial lands, so far as I have heard. The summer has been very hot and dry.

Very respectfully, your obedient servant,

DOUGLAS M. HAMILTON.

C. V. RILEY, *Chief U. S. E. C.*

EVERGREEN, ALA., *August* 24, 1879.

I beg leave respectfully to submit the following answers to your circular (No. 7) concerning the Cotton Worm:

1. About the year 1817.

2. In 1825, or about eight years.

3. It is most generally dreaded after a mild winter, but experience teaches that this fear is ill founded. It is probable that a greater number of the chrysalids survive a mild winter than a severe one, but the present season proves that they cannot all be destroyed by cold, for having passed through the severest winter since their advent, the worms are at this time (August 24) destroying the cotton in some localities, and bid fair to make a clean sweep within the next two or three weeks.

4. Wet springs and summers are decidedly more favorable to their production than dry ones.

5. On or about the 25th of May, 1873.

6. In moist, rich soils, where the weed is most luxuriant.

7. I know but little from actual observation. I have seen the chrysalids in the ground exposed by plowing, sometimes under turfs or logs, or anything that affords protection from cold and wet.

8. None. Every variety of birds feed upon them, but there are not enough birds in a State to devour all the worms on a single plantation. The English sparrow is the only bird that could be introduced which would be available, and it is not considered practicable to try him, for the number required to do the work would require a vast amount of food at all times, and of itself become a greater pest to the farmer than the worm.

9. All efforts in this direction have been fruitless. The writer is of the opinion that as soon as the moth emerges from the chrysalis it proceeds at once to deposit its eggs (of which it contains a vast number), and are not attracted by anything to be eaten until they have performed that function. They are attracted by any saccharine substance, like sugar and water or molasses and water, but, for the reasons stated above, they are considered of little value. Fires or lights will also attract them, and, if not too expensive, might be more available than poisons. Owing to the uncertainty of the time of their advent, and of the very short time required for the laying of their eggs, the plan of destroying by fires can hardly be made available, however.

10. It is immaterial whether the poison is contained in vessels or spread upon boards, trees, &c.; they are as likely to find it at one place as another. The writer has seen myriads of them destroyed by dropping into evaporators used in making sirup. This, however, is never observed until late in the fall, after the cotton is destroyed and the color of the moth is changed. The last crop of worms are black, or nearly so, and the moth springing from them is of a darker hue than the first seen, and are non-productive. Those coming from the green worm are brown, and supply all the eggs.

11. There are none known to the writer.

12. I have no experience with jute, but have seen cotton grown among corn escape the ravages of the worm when all other was destroyed. The writer does not favor the plan, however, practiced by many cotton planters, of crossing cotton with corn at from 12 to 20 feet, inasmuch as the effect of retarding the progress of the worms is not successfully attained, and the corn thus made will little more than pay for the cotton lost, besides impeding the cultivation of the cotton in case the corn is blown down or bent by wind (as happens as often as not). In the opinion of the writer, the better plan is to plant *cotton in corn; i. e.*, after securing a stand of corn early in the spring, plant a hill of cotton between each two hills of corn, so what corn is made may be considered clear gain. If the corn is not bent, the cotton may be worked after the corn is "laid by," and if it is bent, so as to prevent the cultivation of the cotton, nothing is lost by having the cotton there. Of course this plan can only be made profitable on good land, where the cotton will continue to grow after the fodder is pulled. The writer saw last year, however, on poor land, more than 200 pounds of cotton per acre gathered from land where 15 bushels of corn were grown, and this with one additional working. Moreover, cotton grown alone immediately by the side of this corn and cotton was entirely destroyed by worms, *while that grown with the corn was untouched.*

13. Nothing. From experience in the use of a tea or decoction of the China berry on cabbage, to drive away worms, bugs, &c., the writer is induced to believe that the same might be used with success on cotton. It is well known that all insects or vermin are averse to the taste or proximity to this plant, and the writer has no doubt that a thorough application of it to cotton, made at the proper time, would drive off the worms. I will not undertake to say that it is practicable, for the labor of making the tea and applying it may overbalance the profit. In other respects, however, it has the advantage of being cheap and harmless.

14. I have seen the cotton plant scorched and ruined by using the poisons in too concentrated a form, but have seen no injury to persons or animals. Being a deadly poison, however, the Paris green will certainly kill animals as well as worms if taken

into the stomach. It acts as a poison also when introduced into the system through the blood, and should consequently be handled with a great deal of care.

15. Of the means yet discovered, no agent has the advantage of Paris green.

16. For the protection of cotton of average size of weed, an outlay of about $2 or $2.25 per acre will be incurred in this locality, including the cost of the poison, flour or gypsum for mixing, and labor of applying. In places where water can be had without too much labor the cost might be a little less; but comparatively few farmers have this natural advantage.

The writer takes occasion, in this connection, to suggest a solution of the "caterpillar question" in a very few words. Let every cotton planter in the South adopt a system of reduced acreage, high manuring, and thorough cultivation. Let him plant only such lands as will return a large yield, say one, two, or three bales per acre, and he can afford to apply Paris green and save his cotton. Of course, this can be done in most sections of the South only by high manuring; but no farmer should plant more cotton than he can make remunerative. If he can manure but one acre, let him plant but one. This system would not only save the cotton from destruction by worms, but would immeasurably improve the financial condition of the South and the whole country. The farmer, having less cotton planted, would have more land to devote to grain-crops and stock-raising, and after one or two years the market value of cotton would be so enhanced that he would receive as much money for his few bales as he now does for his many.

Very respectfully,

ROBT. A. LEE.

C. V. RILEY, *Chief U. S. E. C.*

HENDERSON, TEX., *November* 27, 1878.

In reference to our Cotton Caterpillar, it is hard to drive to an uncontested conclusion, as there are almost as many opinions as there are cotton farmers in the South.

I am a native of Louisiana, sixty-four years old, and have been growing cotton the greater portion of my life; still I know but little that is worth telling in reference to this terrible Southern pest. The first Cotton Caterpillar I ever saw was in Holmes County, Mississippi, in 1846. The second time I saw them, in numbers worthy of notice, was during our last unfortunate war, 1864. Since then they have appeared annually (more or less) in all the cotton States. *They appear to be migratory*, but many deny this, and support their views with some plausibility. But we are taught by experience that they do not appear simultaneously over the whole country, but annually appear in the extreme southern portions of Alabama, Florida, Louisiana, and Texas. We often hear of them four to six weeks before they raise, hatch, and accumulate sufficient numbers to reach the northern portions of these States. The first-comer (or parent) is a small yellowish fly, resembling somewhat our usual summer-evening candle fly. Whether from instinct or not, I cannot tell—but I will call it instinct—the first fly visitors always deposit their eggs in the center of each field. Why so in every instance, if it is not to place himself, as well as his first brood, as far away from birds and other enemies which might annoy them near to the forest trees and woods?

Again, they invariably deposit the eggs in the top—yes, in the bud—of each stalk or plant, for there the little embryo leaf is full of downy fuz, in which the eggs lie closely bedded, elevated high to the dew and warm sun, and soon hatch. Now we have the worm, so small as to be almost unobservable, but safely secured in his downy bed, which down is his food for a day or two, when he begins to feed on the yet small and tender leaf, and eats day and night until he webs up, to reappear another fly. This is our first crop; and from first observation of the fly until the second crop appears is about fifteen to twenty days. This second crop proceed as the first, depositing their eggs in the bud, and this time extend their dominions to three-fourths and

sometimes over the whole field, maturing as before, giving the third crop, which soon finishes the last leaf of the young fruit. I will add that many suppose this last crop, after devouring the crop, deposit their eggs in old hollow trees, old dry fence-rails, dry weeds, or other dry rubbish, to slumber till another year, and then reappear. This does not look reasonable as compared with the observations as above stated; besides, they would then hatch out and reappear at every place where they existed the year previous; so I rather believe they are migratory, and come from the south annually. I am of the opinion that if planters would top their cotton, say three or four inches below the bud, about the time they see the first fly, much benefit would be had. First, the natural place for depositing the eggs would be removed; second, if any eggs had been deposited about the time of topping, the topped part would become dry in a few hours and the egg would perish, or, if hatched, the little baby worm could not feed on the dry, parched leaf, and would thus perish. If, however, he had strength to make his way to a neighboring stalk, he could not feed so young on the lower tough leaves, as he can only survive on the downy part in the bud first and then on the youngest and tenderest leaves. Thus he acquires size and strength in a few days to feed on older leaves.

It is natural that they do not deposit the egg anywhere on logs, trees, or woody substances, or even on grown tough leaves, where the diminutive baby worm cannot feed, thrive, and live; so the last or third crop, if deposited on these substances, would soon become extinct. Therefore they are migratory and come from the south.

Then, as a remedy, I would suggest, first, to work and cultivate fast, get a good growth as early as possible, but, large or small, top the cotton as soon as you see the first fly; second, I would urge, as an additional remedy, to put up poles with martin-boxes on the top, and cultivate and raise our black martin bird. It is a South American bird, innocent and harmless to all vegetation. They arrive here in May, raise their young, and migrate the 1st of September. They are a fine, greedy insect-scavenger, and increase rapidly. Again, they are by nature adapted to the work, because the caterpillar-fly works from about 5 o'clock p. m. till dark each day, and while all other birds retire to roost early, the black martin feeds till dark. In fact, this mode of furnishing artificial homes for birds would invite many of our native birds to occupy these homes, and particularly our bluebirds, which are also fine insect-destroyers. Thus, by largely increasing our birds which feed on these insects, we would be well fortified against the boll-worm fly, which much resembles the caterpillar-fly, both of which appear about the same time, first in small force, and increase very rapidly.

If birds could be distributed over the fields in these artificial homes, they would effectually destroy them on their first arrival, when so few in number. You are aware that in the early history of the Southern States, where the farms were small and few in number, then the forests were vocal with the song of birds. As the fields increased in size the forest decreased, and since our late war the freedmen all, young and old, used every means to procure guns for the purpose of killing game, and no bird, however small and innocent, is allowed to escape their deadly aim. Nor will I stop in condemning the negroes for this unwise practice, but the same holds true of our idle young white men, many of whom indulge in the practice as mere sport. Our forest songsters are now seldom to be seen, their songs are hushed, and the moaning noise of the wind in the tree-top is undisturbed by the note of the bird. Laws should be passed by all the States to put a stop to this unwise practice.

Yours, truly,

JNO. M. WOLKOM.

C. V. RILEY, *Chief U. S. E. C.*

HEMPSTEAD, *Waller County, Texas.*

I herewith send replies given by different farmers in this county in answer to the question asked on the first page, and you will see that there is a variety of ideas as to the manner of hibernation.

The questions in Circular No. 7 having been carefully answered, to your first circular, I do not think I can add any more information, save perhaps to reiterate my firmer belief in what I had stated, to wit:

That the worm has four changes: from chrysalis to moth; moth to egg; egg to worm; worm to chrysalis.

That the moth is short-lived, from five to seven days; is not an eater; always an egg-layer; remarkably timid; a strong light readily attracts them; they perform their mission and then die.

That the egg hatches in from about five to seven days; is deposited on the under side of cotton leaf in regular layers.

That the worms as they hatch proceed at once to do their mission, and take from seven to nine days to perfect themselves, when they begin to spin their web. In about thirty-six hours the chrysalis—the hibernator—is ready for its long or short sleep, according to the protection or exposure, the heat or cold, surrounding it. It is the *seed*, that chance may throw on stony ground and it will perish, or it may fall in some sheltered spot and there be preserved through any winter. The cause of so few appearing in spring may, and I think does, result from the fact that so few chrysalids fall into nooks or places suitable to protect them through the winter, and are destroyed by winter's cold or their own decay.

I suggested that perhaps the plant on which the egg was deposited might give direction or impress the worm with desire to eat of that plant. I am ready to change or modify my views, and say that now I think the plant on which the worm feeds must have the effect to determine the plant for the future worm.

I have observed this year that the Cotton Worms, after finishing the cotton, attacked the crab-grass, and have eaten it up—nothing left in the corn field for stock to eat; looks like a frost had killed it. These worms *did not retain* their *cotton-leaf* color, but underwent a great change; the black streaks were obliterated and green color took its place; the half-grown worms became stouter and shorter and more sluggish and of a dirty green color.

The change in the worm is so great that the identity of the worm has been most stoutly denied by very good farmers, who have said, "if you examine them closely you will find them to be the genuine 'grass' worm." If all things work according to my views, we shall be visted by "grass" worms next spring, which will eventually attack the cotton.

9. A large and strong light carried slowly through the fields will surely destroy the moth; but this must be kept up once a week, and the moth must be startled from its rest.

13, 14, 15. Paris green cheapest, used in powder; if too strong, will kill plant and any animal that will eat the plant. Should be used only sufficiently strong to kill worm and not damage the plant. Animals should not be allowed in fields where Paris green is used.

In regard to the answers herein given, my aim was to get the farmers' individual opinion unbiased, and after taking it down would read it, and ask if I had expressed him correctly.

P. S. CLARKE.

C. V. RILEY, *Chief U. S. E. C.*

Question addressed to farmers of Waller County, Texas.—What is your opinion as to the manner or mode of perpetuation, or preservation of the Army or Cotton Worm from one year or season to another? In what condition does it hibernate?

Answer by J. A. PEEBLES.—The miller, or fly, makes its deposit of "eggs" in the

fall in the ground; they hatch out in the summer, these eggs reproducing the miller. The miller subsists on some kind of food. Believes in a male and female fly, and copulation.

Answer by Dr. J. J. PERRY.—Believes it is propagated in the chrysalis from the chrysalis burrowing in the ground, there remaining intact till the period of incubation has expired, when the moth appears. Duration of incubation from six to nine months. Thorough system of winter plowing would eradicate them.

Answer by JOHN PEEBLES.—Bclieves the eggs are deposited in the ground by the fly; there remaining till cold weather is over, when they hatch as a fly. They (the fly) subsist on some kind of food while existing; they copulate.

Answer by A. T. BEDELL.—Some of the eggs remain unhurt by the winter and are hatched out in the spring, and in this manner are perpetuated.

Answer by Dr. L. W. GROCE.—Believes the eggs are deposited under the bark of the cotton-stalk, under and at the ground, and in this manner lie dormant through the winter and hatch ont iu the spring. No copulation.

Answer by J. C. RALSTON.—The fly deposits its egg, which becomes a worm, which becomes a chrysalis, which becomes a fly, which again deposits eggs. The fly does not eat. The egg is the medium of perpetuation, which holds through the winter in a capsule.

Answer by Dr. WILLIAM CLINTON.—The flies or moths are brought from the perpetual cotton fields of South America by strong southern breeze. Each year terminates them, and again are brought by southern breeze.

Answer by FRANK COOKE.—Originated in Southern States, is a hybrid or cross from common grass-worm; deposit their eggs on cotton stalks or in the ground, from which comes the first crop, these eggs lying in the ground till spring. Cau be destroyed by dcep plowing or freezc.

Answer by Dr. R. C. WATSON.—Thc moth deposits eggs on leaf, hatches in worm, then goes into chrysalis; depends on peculiar conditions how long it remains in this state, from which comes a moth. Thc chrysalis hibernates, the fly copulates.

Answer by R. G. WHITE.—The chrysalis drops from the stalk and becomes covered under gronnd; in this manner is preserved during thc winter. The moth copulates.

Answer by B. F. ELLIOTT.—Believes the caterpillar goes in the ground in the fall; then becomes a chrysalis; remains dormant till next summer, when it hatches out a fly. Thc fly eats, copulates, lives thrce or four weeks.

Answer by ZACK WOOLEY.—The moth deposits eggs in the fall, which are preserved through thc winter and hatch out a worm in the spring, which attacks vegetation; then go to work, web up, and turn to the miller again, which deposits eggs; these eggs hatch out the worm that goes to work on the cotton. The fly eats, copulates, lives three or four weeks.

Answer by M. G. STANLEY.—The caterpillar itself deposits eggs in the ground in the fall This egg becomes the miller. The fly copulates; does not eat.

Answer by W. W. MOORE.—The worm passes into chrysalis and in this condition remains till spring, when it emerges a butterfly. No copnlation; no eating.

Answer by A. A. PETTUCK.—The worm gocs into the ground; there changes to chrysalis and remaius till spring, when thc bntterfly comes forth to deposit eggs to start the worm; fly copulates and eats.

Answer by W. J. BUCHANAN.—They go into thc stalks of cotton or small stumps at or near the ground; there they stay as a worm until we see them as a fly in the spring. The fly copulates; lives upon jnices of flowers.

Answer by WILLIAM AHRENBECK.—They pass into the ground in the chrysalis state; there remain during winter, become perfected by spring, and come out a fly in spring; must be male and female; do not eat.

Answer by DANIEL LOGGINS.—They go into the chrysalis and remain in that condition till next ycar, when they come out a butterfly; copulate; do not eat; fly lives four days.

Answer by Dr. R. H. BOXLEY.—They pass into chrysalis state, and in this manner hibernate, when they emerge the next year a fly. The fly copulates, but does not eat; lives three days.

Answer by N. K. ALSTON.—The caterpillar deposits eggs in the ground in the fall; they lay there all winter and come out a fly in the spring, which deposits eggs to make the worm. Male and female fly; copulate. They must eat; fly lives two or three months.

Answer by JAMES LOGGINS.—The caterpillar changes into some other insect—don't know what this is—which hides itself till spring and then comes out a fly; fly copulates; feeds on something; lives nine days.

Answer by JOHN LOGGINS.—The caterpillar burrows in the ground in the fall; it changes there to chrysalis, and in the spring comes out a butterfly; fly copulates; lives on juices of plants; exists about twenty-one days.

Answer by J. F. GROCE.—The fly goes into the ground or secretes itself in some hidden place in the fall to protect itself from winter's cold, and comes out in July and August to deposit eggs; no copulation; no eating by fly.

Answer by JOHNSON HENSLEY.—A small butterfly lays its eggs in the fall in old trash, leaves, or bark of cotton-stalks. These eggs remain intact during winter, and in months of June and July hatch out the worm. The fly copulates and eats juices of vegetation. First saw the worm is Washington County, Texas, in year 1834, on Milk Creek.

Answer by WALLER COCHRAN.—The caterpillar burrows in the ground; there changes into chrysalis, and in this condition stays till proper time to hatch out a fly. The fly copulates; does not eat; live two or three weeks.

Answer by J. D. MITCHELL.—They remain in chrysalis state in any place suitable to protect them during winter; in spring it comes out a fly, which deposits eggs; fly copulates; subsists on juices of plants; live fifteen or twenty days.

Answer by H. LEWIS.—They go through the winter in the chrysalis state. After eating up the cotton (1879) they took to the crab-grass in the corn-field and devoured it completely. Did not discover any change in the color of worm after eating the grass. The fly lives six or eight weeks.

Answer by Dr. E. MONTGOMERY.—The chrysalis is the medium of perpetuation during and through winter. The fly eats and copulates.

Answer by J. H. DAVIS.—The chrysalis for the most part turns out a fly, but sometimes a cross between a chrysalis and worm. This cross goes into the ground and into trash and lays there till spring, or a suitable time, when it comes out a fly. Sometimes, when the weather is not suitable, very few develop, and consequently we have very few worms. The fly does not copulate, and does not eat.

Answer by THOMAS ARMER.—The fly secretes itself in some warm place, where it hides till winter is over and warm weather comes to bring it out; male and female fly; copulates, but does not eat. Believes the worm eating up the grass is a totally different one from the Cotton Worm.

Answer by THOMAS RAY.—Believes they pass the winter in the chrysalis state; have frequently seen them plowed up out of the ground; male and female fly; fly lives about ten days. The worm now eating up the grass is a totally different worm from the Cotton Worm, it being of a green color and smaller.

LIVINGSTON, SUMTER COUNTY, ALABAMA,
September 5, 1879.

Maj. J. G. Harris handed me your circular and letter, with request that I should reply to the same. I herewith inclose my essay on destroying the Cotton Worm, written in 1873, which will give my answers to many of the questions.

1. This county was occupied by the Choctaw Indians till 1832, and was mostly set-

tled up by the white people in 1833, and rapidly cleared up and planted largely in cotton.

2. The first year of the worms was in 1842 (so far as I know), when they stripped the foliage from the cotton in September.

3. They are generally worse after a winter of even temperature, not very cold. Last winter was a very cold one, and the worms have worked about in patches through the two past months, but not extensively damaging the cotton, though the weather has been very wet, and the moths are now appearing in considerable numbers. We have them in damaging numbers one or two years, and then an intermission of two or three years, and sometimes alternating in different sections of the county.

4. Wet summers are much the most favorable for their multiplication. In dry, warm summers they do not multiply.

5. By the middle of May, but generally not till June, in their earliest but small generations. In 1873 the destructive brood—second or third generation—stripped the cotton of foliage in July and early in August; usually not till the last of August and September.

6. They generally appear earliest in "bottom lands" and prairie, where adjoining thick-set wood lands.

7. They hibernate in the moth state; and also the very late formed chrysalis exist in that state through the winter, where protected from severe cold by grass or other herbage or covering, and perhaps in the ground.

8. All our insectivorous birds consume the worms, and the moths to some extent, but which are not out on the wing except at late evening and at night, or at a dark, cloudy evening.

9 No methods to destroy the moths have proved effectual; but fires attract them most, when some are burned or their wings disabled, and molasses will stick and hold some when attracted by a candle standing in the plate or vessel. This is the only known means of destroying the moth of the boll-worm, and preventing the great damage to the cotton-crop by their more obscure depredations, and might be effectual to lessen them much by the persistent use of great numbers of these plates of molasses, with lamps or lanterns so made that they could fly into and be burned, and thus destroying them before laying their eggs in the cotton-blossom. But sugar or sirups do not perceptibly attract by themselves.

10. These things are only useful in plates, when the moths are attracted by lights.

11. Know of no flowers which attract the moth, except the cotton-blossoms attract the moth of the boll-worm, in which it deposits the eggs, one in each blossom; and these blossoms are expanding from early June to September which perfect cotton, and thence on into October, but which are too late to mature.

12. Know nothing of the influence of jute grown near cotton.

13. Know nothing better than Paris green or cheaper than arsenic to destroy the worms, but have an essay, in pamphlet, published in 1874, on "the Texas Cotton Worm Destroyer," discovered and patented by J. D. Braman and A. Robira, "which is a salt of arsenic that readily dissolves in cold water," "four ounces of which, dissolved in 40 gallons of water, and costing 25 cents, and sprinkled over an acre of cotton with a watering-pot or sprinkling-machine, will effectually destroy the worms and preserve the cotton." Patented by Robert Rennie in 1874 And they claim that it is better, safer, and cheaper than the other articles named.

14. Have not known of any injurious effects from the poison to men or animals, but heard of some through want of caution. The cotton leaves are quickly crisped and killed by the application of more poison than is necessary to kill the worms or in too concentrated a form.

15. The best methods of destroying the worms are given in the above answers and in my essay, and the most expeditious, with the cheapest, will be to use the poison in a dissolved form, and applied with *a fountain hand-pump.*

16. The cost per acre to protect a crop of cotton by killing the worms with poison

will be from 25 cents to $1 and about half a day's work with the fountain hand-pump, to apply the poison in water, dissolved; or with sifters lined with muslin, to apply the poison in dry form, well mixed and incorporated with plaster or flour, when the cost of the flour may be added to the above-named cost, which was given only as the cost of the poison. What would be the cost of lamps, lantern traps, vessels, and material to destroy the moth, particularly that of the boll-worm, which does a vast amount of injury to cotton crops, or even to materially lessen the numbers, cannot now be estimated, as it has not been sufficiently tested. The fountain pump costs about $5.

Respectfully,

I. D. HOYT.

Prof. C. V. RILEY.

PARISH OF CONCORDIA, LOUISIANA,
Lake Concordia, August 8, 1879.

1. About the year 1810 the planters of this parish and the adjoining county of Adams, most of whom owned property in both localities, commenced abandoning the culture of indigo and substituted that of the cotton-plant.

2. The first Cotton Worms or Caterpillars were noticed in 1840, both in this parish and in Adams County. They were noticed in August, cutting the cotton in rank spots. The second crop stripped the rank cotton in September. The appearance of an heretofore unknown insect caused a meeting of all the leading planters, and it was generally agreed that, owing to the luxuriant rank growth of the cotton stripped by the worms, that they were rather a benefit than otherwise, leaving the bolls exposed to the sun and thus insuring their ripening. The worms again appeared in greater numbers in 1844 and 1846, doing considerable damage both years, especially in the latter year, as they stripped every field in the county before maturity. They continued to appear in numbers at intervals up to the breaking out of the war, but, as the culture of the cotton-plant was pushed forward very early under the then existing system of labor, the yield was not much shortened by the stripping of the leaves in September, and many planters continued to think that the large cotton in new grounds, of which there was a considerable quantity, was benefited by the loss of foliage.

3. The character of the winter seems to have very little influence upon the propagation of the Cotton Worm; its development in greater or less numbers seems to depend *principally* upon the character of the summer season. A wet, rainy summer, causing a rank, succulent, growth of the plant, is peculiarly adapted to their propagation in countless numbers, even apparently shortening the period between their reappearance from 21 to 18 days, and causing them to appear in such numbers in what is commonly called the second crop (in August) as to almost destroy the leaves on the cotton and not leave sufficient foliage to sustain the next generation, in September, for more than half their allotted 7 days. For instance, the winter of 1872–'73 was one of the coldest known in this latitude for years. Worms were noticed in the latter part of May, and by the last of August the cotton-fields of this parish were perfectly bare, and yet still another crop of worms hatched in latter part of September, and destroyed crops saved by application of Paris green.

4. Wet summers are almost essential to the reproduction in any great numbers of the worm. Many of the eggs do not hatch in dry weather, and then the many enemies of the worm have a better chance to destroy them.

5. In 1868, the first year of my experience as a planter, I noticed a few in spots about July 15. August 7 they were quite numerous in spots. August 25 they reappeared, and injured the crop considerably; worms green, with two rows of yellow with black spots down back. September 8 a more numerous crop stripped portions of the field. September 25 the green, with black stripes down back, appeared, and soon stripped the plants of every leaf and small boll. In 1869 I found a few worms as early as June 24, full grown, pale green, marked with white and yellow spots. July 15 a few were noticed in rank cotton. August 7 they were quite numerous in spots of same

character of cotton. August 27 the green and black spotted worm "chopped" the leaves badly over whole crop, and successive crops appeared each week, September 2, September 8; and then on September 20 the green and black striped worm commenced stripping the crop. This was a very wet season, cotton growing very large, and despite the loss of leaves, the yield per acre was about one bale of 400 pounds weight.

In 1870 the season was one of the dryest ever known. I did not find worms until September 15, and then the green and black striped. They were not in sufficient numbers to do any harm. In 1871, the first worms noticed from 1st to 15th July, green; reappeared August 15, green, with black spots; September 10 appeared in considerable numbers, green, black striped, but did not entirely strip the plant; extremely wet spring, but dry summer. In 1872 the first noticed were on September 9, green, yellow stripes, black spots; reappeared July 15, all sizes and stages; August 20 to 25, heavy crop of green, black striped, stripping the cotton early in September. In 1873 found first worms latter part of May; had seen flies around buildings on warm days in February; did not pay much attention to their reproduction until July 25, when the green and black spotted ones appeared in considerable quantities. August 15 the green and black striped worms came in myriads, and made short work of the rank, succulent cotton, the growth of a rainy summer. I saved 900 acres by applying Paris green; 600 acres in one part of the parish was destroyed by October 1, the flies having been blown into my fields from adjoining plantations by a heavy wind the week previous; 300 acres on another plantation, being isolated, was not again molested.

In 1874 the first and second appearances were noticed latter part of July and August; September 4, considerable numbers of all sizes and grades; September 14, numbers sufficient to strip the cotton crop, as it was mostly planted after an overflow. Applied Paris green in places, but the worms disappeared, probably destroyed by birds and insects. In 1875, although not an unusually dry year, no worms were noticed. In 1876, found a few worms on July 12; August 2, considerable numbers in spots; August 22, reappeared in considerable numbers, all grades and sizes, but by September 7 they had mostly disappeared, it being very dry and hot, and birds and insects being plentiful. In 1877, noticed worms in July; August 10, good many; August 16, in sufficient numbers to justify use of Paris green in places, which saved that portion of the crop, but the worms reappeared in force September 20, and by 25th there was not a leaf left. In 1878, full-grown worms seen August 9, earlier broods not noted; August 21, full crop green, black spots, out over large area of the country, though not general; again used Paris green with success; September 12 to 19, cotton stripped. In 1879, the worm was first seen about June 20; about July 15 it was again observed, and now they are found through the fields in all parts of the parish, always the pale green, yellow, striped, and black spots. We look for a pretty full crop about 25th, and a destructive one about September 10, with continuance of this favorable showery weather, unless some natural causes, in way of birds or insects, prevent their propagation.

6. The Cotton Fly is a shy insect, and seeks shelter in large cotton, which grows in damp spots; there the eggs are deposited and the first worms hatched.

7. The moth hibernates between the bark of old logs and dead trees in the lofts of barns, gins, and outbuildings, protected between shingles, or in crevices, in a state of torpor. Only a few survive the rigors of winter; hence the very few which appear in the early spring. It is my impression that the moth is impregnated in the fall, but this is simply a matter of conjecture.

8. Nearly all birds and fowls devour the Cotton Worm with avidity, but the common black-bird, which to a considerable extent hiberuates in this region and breeds here, is the greatest enemy among birds. The common red wasp, the small red ant, a species of large green spider that I have never observed except on the cotton plant, a hexagon shaped bug, green and sometimes brown (it being apparently of a chameleon nature), flat and emitting a very disagreeable odor when roughly touched, armed with a long, sharp bill which it carries under the body—commonly called the pump-

kin-bug—and lastly, the Ichneumon fly, all destroy the worm in its various stages of transition—the ant even taking the larvæ from the underside of the leaves. The wasp and Ichneumon fly, where numerous, seem to be most destructive.

9. The experiment of saving a crop from worms by destroying the moth was most effectually tried prior to the war when well-controlled labor was at hand and money was plentiful, and since then some enterprising men have spent much money and time in the vain attempt to save their crops by this means, but none in this section have succeeded. There are many, many times more worms hatched than necessary to complete the work of destruction; besides, my belief is that the moth deposits its eggs before leaving shade of the thick cotton, and having accomplished its destructive mission then flies about in the air.

10. The moth is attracted by the light, and my observation is that the vessels containing molasses, &c., being placed around the light, serve more to entrap than attract them. The moth is very destructive to fall fruit, puncturing it so soon as it begins to ripen.

11. Have never noticed moth about flowers.

12. Have never seen the experiment tried.

13. Arsenic itself is used by some persons, they claim, successfully, and of course, as it only takes about one-quarter of a pound to an acre, it is the cheapest poison that can be used; but owing to the great weight and the perfect insolubility of arsenic with water, I have found it a very unsatisfactory application; first, unless incessantly stirred and shaken it precipitates and clear water is applied, and the Cotton Worm lives on.

Secondly, if too much is carried in suspension on to the cotton it burns all young bolls and leaves. The Texas Worm Destroyer, a salts of arsenic, has considerable reputation and does dissolve in water, but, individually, I have been unable to attain the happy medium of mixture—either the worms are not killed or the cotton is much burnt when applied strong enough to kill. A solution of arsenic known in this section as "Early Bird," and which dilutes readily with water, has the same objection—it has to be made too weak to kill worms or it kills worms and burns cotton at the same time. Hence I find myself compelled to adhere to the Paris green, even when run up to 75 cents per pound, as was the case in 1873. Have tried sundry other poisons without effect. Am now having prepared several solutions of Paris green with ammonia for experiment. As the great trouble is that Paris green will not dissolve in water—being only held in a state of suspension and precipitating so soon as the water ceases to be agitated—the water into which it is put has to be constantly stirred, and the 2-gallon pots from which it is sprinkled have to be constantly shaken violently; therefore we have been, so far, unable to use any mechanical process of sprinkling.

14. When applied too strong, say in greater proportion than 1 pound of green to 40 gallons of water, or 6 pounds of green to 200 pounds of flour and land-plaster, the mixture will burn and kill young bolls, forms, and tender leaves, and thus do as much harm as worms. Occasional instances of men being nauseated while mixing the green with flour and plaster, or even while sifting it on the plant, have come to my notice; but a single dose of the antidote, hydrate oxide of iron, always gave relief. A good many instances occur of men becoming chafed by riding, and the flour mixture and even the water getting on their persons causes soreness, and sometimes swelling of the parts accompanied by an eruption of white pimples; but this is soon relieved by the use of the antidote externally or an occasional application of sweet oil and sprinkling of flour. This trouble is prevented by use of oil-cloth aprons and free use of strong soap after working with the mixtures. Mules are sometimes made sore around and under the tail and on flanks and shoulders if care is not taken to wash them clean of the flour mixture, which becomes caked in the hair.

15. I have found the application of Paris green the *surest* poison for destroying the worm, applied in the early morning and late evening, mixed with flour and equal parts plaster of Paris and land plaster, 6 pounds green to 200 pounds, carefully and

thoroughly mixed and sifted before using, and then sifted on each side of the row through a No. 24 sifter, and during the heat of the day when the leaves are dry, ¼ pound to 1 pound green to 40 gallons water, sprinkled on each side of the row with a 2-gallon watering-pot, ordinary sized rose, perforated with holes about the size of a knitting-needle. The drawbacks the cotton-grower has to contend with are many. First, if the worms come early, say about August 1, in sufficient numbers to justify the use of green, the next crop, which comes about September 1, will destroy his crop, besides the work of cultivation is not completed. If they do not appear until 1st to 10th of September, he is then compelled to devote his time to picking the crop on sandy lands, and a loss of a week from this important work results eventually in great loss. If the worm appears in force about the middle of August the planter is then better prepared to destroy them, and the plant in a better condition to justify the expense; but often the weather is very showery, and much of the green is washed off, and the plant is partially stripped before the worms are killed; also, now that Paris green is so extensively used for this purpose, the article is very much adulterated, and while he pays less apparently per pound for it, it requires more of it to same quantity of flour or water, and even then it is not so destructive. Our great need is a *cheap, soluble* poison, which will dissolve thoroughly in water and kill the worm and not burn the cotton.

16. The cost of application, outside of first cost of the Paris green, depends upon a good many contingencies—convenience of water, size of cotton plant requiring more or less of the mixture to the acre. Where applied mixed with water and the water is convenient, as is generally the case in this parish, it will cost from $1 to $1.50 per acre. When applied mixed with flour and plaster (by far the most efficacious process) it will cost from $1.50, at the lowest, to $2.50 per acre. The best and surest plan for the cotton-planter to protect himself against the ravages of Cotton Worms is to list up his lands in December, and very early in January replow, plant early, and force the plant to maturity by constant, judicious cultivation. This mode costs as much per acre as the application of Paris green, but it is money better spent, as the soil is kept in better plight by such a process. Still, under favorable circumstances, I am a strong advocate for the use of Paris green, or any other efficient poison, to kill the worm, and use the green whenever my crops are threatened with injury by the worms.

Very respectfully yours,

F. S. SHIELDS.

C. V. RILEY, *Chief U. S. E. C.*

NATCHITOCHES, LA., *September* 29, 1879.

First, in order to answer your questions intelligently, I will give a slight outline of the geographical location and situation of the parish of Natchitoches. It is situate in the northwest part of the State of Louisiana, the greater portion being immediately south of the thirty-second degree of north latitude, its greatest length being from southeast to northwest. It had a population, according to the census of 1870, of 18,255. Had in cultivation last year, or rather in the previous year (1877), in cotton, 23,800 acres, and produced 13,949 bales of cotton. The lands are particularly fertile and productive, yielding the greatest abundance of the fruits of the earth with a small outlay of labor. As to your questions:

1. I answer only for the parish of Natchitoches, La. Cotton was first planted in this parish about the beginning of this century.

2. The first appearance of the worms in this locality was in the year 1823, late in the autumnal season, and they did but little damage to the cotton plant. The second time was in the year 1840, doing again very little damage, and creating no alarm in the minds of the planters; but when they came again, in the year 1844, they did considerable damage, causing serious alarm to those engaged in planting, making them ask the question if it would pay to continue the business. By the end of the month of August every leaf was stripped from the plant as if a killing frost had fallen.

After this, confidence was restored and cotton planted extensively until the year 1846, when again the crop was destroyed. The damage was considerable, and the yield lessened at least 25 per cent. After this no particular attention was paid to the worms until after the close of the late war, since which time they have reduced the yield year after year, until they became so destructive as to almost deter planters from engaging in the business.

3. In order to answer this question intelligently I have obtained the following facts in regard to the appearance of the worm from the year 1867 up to and including this present year, 1879.

Rain for the months of April, May, June, and July:

	Inches.		Inches.
1867	29 1/20	1874	17 3/20
1868	18 1/20	1875	7 7/20
1869	22 8/20	1876	9 2/20
1870	19 5/20	1877	20 2/20
1871	21 6/20	1878	15 19/20
1872	23 2/20	1879	16 14/20
1873	23 13/20		

As to the temperature of the months of December, January, February, and March, Dr. F. Johnson says: "As to mean temperature of these same months, the variation is too little to have any influence on the question before you. Compare your notes on Caterpillars, and see if you can find any mutual connection between temperature, rains, and worms. I do not think there are any satisfactory bonds of connection."

Caterpillars in—

1867.—First appeared about 6th of June; destroyed crop last of July.
1868.—First appeared 1st day of May; destroyed crop 10th of August.
1869.—First appeared 20th of June; destroyed crop 20th of August, partially.
1870.—First appeared 20th of June; destroyed crop 20th of August.
1871.—First appeared 15th of June; destroyed crop 20th of August.
1872.—First appeared 20th of June; destroyed crop 20th of August.
1873.—First appeared 10th of June; destroyed crop 1st of August.
1874.—First appeared 20th of June; destroyed crop 20th of August.
1875.—First appeared 20th of June; destroyed crop 20th of August.
1876.—First appeared 20th of June; destroyed crop last of August.
1877.—First appeared 20th of June; destroyed crop 20th of August.
1878.—First appeared 15th of June; destroyed crop 25th of August.
1879.—First appeared 20th of June; did not destroy crop.

4. This question is answered by the preceding answer so far as figures can, and from the statistics it appears that weather has no particular influence on them. You will observe that the months of April, May, June, and July, of 1869, were among the wettest of the caterpillar years, yet the crop was only partially destroyed, and for the same months of the year 1876 we had nearly two-thirds less rain and the crop was destroyed as usual. As to their destruction by the ants, that will be more fully explained later on. The plant during a dry spring is of very slow growth, and may not be able to furnish the necessary *pabulum* for the life and growth of the worm. This might be accounted one of the causes of a wet year favoring their development, there is more surface and food for them in a wet spring than in a dry one.

5. They have frequently been seen as early as the first days of the month of May, notably in the year 1868, when they appeared in great numbers in some localities, and did considerable damage to the cotton plant. Many planters were much alarmed at this early appearance, and thought themselves ruined again. The plant was, however, yet young and recovered from the damage, and a pretty good crop was made.

6. In the low moist places when the cotton is greenish and more tender.

7. The insect undoubtedly passes the winter in the butterfly form, which is the fourth and last stage of their existence. They belong to the species *Lepidoptera*, and genus *Papilio*, and are the proceeds of the chrysalides from the caterpillars. They are about seven-eighths of an inch long, of a dark greyish color, not so pronounced on the under side of their wings, with a characteristic dark circular spot on each wing. The last seen of the caterpillar in the autumnal season, when the crop of cotton is destroyed, is in the form of the chrysalis, for after they eat all of the cotton leaves they proceed to "web up" on any leaf that will afford them protection. This chrysalis produces the butterfly, which immediately prepares for hibernation It is my opinion that they seek winter quarters before they mingle in concourse with the males, hence their eggs are not fertilized until after they come from their torpid state in the spring of the year. They may be seen in the warm days of January, February, or March, near the eves of houses covered with shingles, or in corners of fences made of rails with the bark on them. Just before sunset, after one of these warm days, they will come out and fly around. At this time they do not possess the same brilliant colors that they do in spring and summer when they are depositing their eggs, and one not perfectly acquainted with them might mistake them for another species. They therefore pass the winter in the butterfly form, in a semi-torpid condition, yet, strange to remark, *en passant*, the first thing seen of them in the spring of the year is the worm itself.

8. First, birds (*Aves*) of various kinds and conditions feed more or less on them; among others I will mention the mocking bird (*Orpheus polyglottus* of Linnæus). This bird feeds extensively on the Cotton Caterpillar (*Aletia argillacea*) in the early months of its existence; but they are not gregarious, hence their work is little appreciated in this direction, they not being disposed to go in flocks or localize or concentrate their destructiveness.

This present year (1879) the Cotton Worms have not developed as rapidly and as numerously as they have done usually heretofore, and among other causes retarding their progress has been pointed out as their great enemy the red-winged black-bird (*Agelæus phœniceus*). This bird has been seen in large flocks in the cotton-fields very early this year. These birds have been seen frequenting our fields and forests in great numbers late in the autumnal season, but have never been known here in the months of July and August before. One planter told me that he saw one flock of at least forty thousand in the cotton-field! This number may have been considerably exaggerated, but there is no question that they have been in the cotton-fields during these early months, July and August, in very great quantities, such as have never been seen before. I have been informed that they feed upon the worms in three of their forms, the butterfly, caterpillar, and chrysalis. These birds should be protected and permitted to build their nests undisturbed by the hunter's shot or idle boy's hand. Many other solitary birds feed upon them, but their work is not appreciated.

As to quadrupeds, there are none known, with perhaps the single exception of the raccoon (*Procyon lotor*). He has been seen feeding on them, and planters inform me that they have seen the tops of the stalks bent and broken, evidently the work of the coon in search of the caterpillar.

Insects. Ants (family *Formicidæ*, order *Hymenoptera*) have always been looked upon as one of the most inveterate enemies of the Cotton Caterpillar, destructive to them in all of their four different forms. They will detach the egg from the leaf and bear it off to their formicary; attack and kill the worm either in its active eating state or when under the torpidity of the second or chrysalis state, and if it is possible for them to capture a butterfly it shares the same fate. It may be owing to their inability to procreate and move about during wet weather that the worms are enabled to escape their depredations. It is a well-known fact that the female ant is winged, hence it is plain to be seen that wet weather will considerably interfere with their proper functional office. The female ants are furnished at their exclusion with two pairs of wings, which after swarming in concourse with the males they almost immediately cast. The office of the perfect or winged female is to provide a constant supply of eggs for the maintenance of the population. Rainy weather can therefore keep the female ant

"cribbed, cabined, and confined" to her prison life; if she is permitted to venture forth it is possible for her to be lost in the storm. The superabundant surface-water remaining after heavy rains will greatly impede the active operations of the "venters," or working ants, whose office it is to supply and protect the colony.

The wasp (Genus *Vespa*, order *Hymenoptera*) attacks the worm, and will carry them off to feed their young, and should they be so unfortunate as to drop one on the ground, *en route* the ants will be certain to pick it up.

There is a small chinch-bug constantly found on the cotton-plant leaf, which undoubtedly feeds on the ova or eggs of the butterflies. They are not numerous, however, and are too small and insignificant to do any great amount of damage or interfere materially with the rapid increase of the worms.

9. The only effort ever made in this parish to destroy the butterflies has been by fires at night. They are easily attracted by the "glitter of a garish flame" at night, and great quantities can be destroyed in this manner. It, however, requires concert of action on the part of a large number of planters, which has never been done. As to attracting them by sugar, &c., it is generally believed that the butterfly does not take nourishment during its short life, or, if it does, the quantity is too small for them to be successfully poisoned.

10. They will be attracted only by the lights.

11. I do not know of any flowers that will attract them. They are not seen on any other plant than the cotton.

12. Nothing.

13. Nothing.

14. First, as to the plant: If the mixture is put on too highly concentrated it will kill leaves, blooms, and bolls. Second, as to man: When any portion of the cuticle is abraded and the mixture allowed to get on this particular place it is apt to cause local inflammation and inflammation of the neighboring lymphatic glands; no case, however, to my knowledge has ever been known to result seriously. Third, as to animals: I know nothing of any serious accident to them.

15. The best method yet tried is the application of the Paris green suspended in water, 1 pound to 40 gallons. The Paris green being the arsenite of copper, it is not soluble in water, and when the two are mixed the Paris green is only suspended; hence it is necessary to keep the mixture constantly agitated, otherwise some portions will be stronger than others, and will in that case be apt to injure the plant.

The mode of applying it differs according to the means of the planter using the poison. Many persons make brooms of the Mayweed (*Anthemis cotula*), which are handy and very convenient; others use the common garden watering-pot with the perforated nozzle, which is expeditious, efficacious, and at the same time inexpensive. The best mode yet found is with the fountain-pump; with this the work can be accomplished with neatness and dispatch without wetting the clothes of the one applying it. The poison must be applied just after the worms are hatched and begin to crawl, otherwise it will be too late. It requires careful looking to find the worms at this stage of their existence. Four or five days after the butterfly emerges from the chrysalides she begins to lay her eggs, on the under side of the leaf, and after about the same time the eggs begin to hatch; then look carefully under the leaf in the locality where you expected to find them, and almost to a certainty they are there. In order to better find them every planter should provide himself with a small magnifying glass, which will cost them only about twenty-five cents. This summer I had in my office one leaf from the cotton plant, and on it there were ten worms and in it at least one thousand holes, yet on handing it to several persons they failed to see either caterpillars or holes until they were pointed out to them.

By request I received the following letter from one of our largest planters:

NATCHITOCHES, LA., *September* 26, 1879.

DEAR SIR: In 1876 I experimented with arsenic to destroy caterpillars, with the following result: 1st, I took one pound of 16 ounces of commercial arsenic, which cost

about 25 cents per pound, dissolved it by boiling in 8 gallons of water; after it was dissolved replaced the quantity of water lost by evaporation; with this 8 gallons I went to work. 1st. Put 2 gallons of the solution in a pork-barrel of water, say 33 gallons, sprinkled two rows of cotton; result of this application was death to both cotton and worms. 2d. I then used 1½ gallons to the barrel of water; same result to the worms, cotton badly scalded. 3d. I then took one gallon of the solution and put it in a barrel of water; this time my solution seemed to be a little too strong, but did no perceptible injury to the plant; the leaves retained their color except in places. A fourth application of three-quarters of a gallon of the solution to a barrel of water was tried and found of sufficient strength to kill the worms and not damage the plant. These experiments were made at the same time Paris green was applied to the balance of the cotton on the plantation, none, however, being used when the arsenic was applied. The rows in which the two last applications were made (*i. e.*, 1 gallon and ¾ gallon to the barrel of water), the cotton lived and bloomed about three weeks, at which time the worms destroyed all of the cotton on the plantation.

Respectfully, H. B. WALMSLEY.

Dr. GEO. E. GILLESPIE.

The Paris green has been sold in this market for $1 per pound, but it can now be bought for from 25 to 35 cents per pound. It is calculated that three-quarters of a pound will poison an acre; however, if the application is made just before a rain, it will be necessary to repeat it. Most planters think that $1 per acre will cover all the necessary expenses.

Respectfully, GEO. E. GILLESPIE, M. D.

C. V. RILEY, *Chief U. S. E. C.*

JACKSON, MISS., *September* —, 1879.

In answer to some of the questions of your circular No. 7:

4. Warm, wet, and cloudy weather favors the appearance and reproduction of the Cotton Caterpillar.

5. Never have known them to appear in the spring when June and July have been wet; the 1st August is about the earliest period in this locality.

6. In cotton of the largest growth without regard to the situation.

7. Observation has led me to believe that the worm in none of its forms lives through our winters in this locality, and also form an opinion in direct variance with science as taught in the schools. I have attempted to arrest their increase when only a few had made their appearance by destroying by hand, but without success; for suddenly, without the possibility of such an increase by reproduction, they would appear in such numbers as to destroy every leaf in two or three days. Again, in another instance, when no worms were in this neighborhood, four days after a diligent, and careful search, when no sign of them could be found, they suddenly appeared, and in three days not a cotton leaf could be found in my field except about one acre near the middle of it, which was planted much later than the rest, not a leaf of which they touched, although some of the branches interlocked; but some weeks afterwards when this patch of cotton had arrived at the same stage of growth it was also stripped of its leaves as the other. In all my observation, the worm when it has exhausted the supply of cotton leaf *will eat nothing else*, but crawls up on the weeds, bushes, and fences, and die.

8. From this experience, connected with the facts of their irregular appearance, and that only under the same conditions of wet, warm, and cloudy weather, which is always unfavorable for a healthy growth of the cotton plant, and that the worm never appears in the spring or early summer, at least, not in such numbers as to be noticed; its power of quick reproduction; its total absence from the cotton plant at that time when it could not escape detection; and the temperature of May and June always high enough for the development of the worm through all its forms, leads me to believe that the Cotton Caterpillar is the spontaneous production of diseased cotton plants.

9. All efforts to destroy and stop the progress of the worm when the condition for its appearance and increase is favorable, has proved futile so far as my experience extends in the cultivation of cotton for thirty years.

Yours, very respectfully,

H. O. DIXON.

Prof. C. V. RILEY.

LARISSA, CHEROKEE COUNTY, TEXAS,
October 13, 1879.

In answer to your 4th inquiry, viz: "Do wet or dry summers favor its multiplication?" I would answer that about ten years ago the Rev. N. A. Davis, now of Jacksonville, in this county, suggested to me the probability that the small red or brown ant, abundant in the South, was the natural enemy of the Cotton Worm and especially effective during dry summers. After two summers' observation, I was convinced of the truth of the reverend gentleman's conclusions. His opinion and two years' observation induced me to write the following to one of our county papers:

THE COTTON WORM (1871).

"The danger from the Cotton Worm is now over and we may review the history of its depredations during the summer. Only a few farmers have suffered save in the anxiety which they have felt during the maturation of their crops. If you recollect, the worm was worse during the few weeks following the rainy season; and as the dry season since advanced, the worm gradually receded and the hopes of the farmer revived. The first generation of these troublesome insects appeared to have taken place in the wettest lands early in the spring, and it was about the second generation that menaced the crops. Wet weather favors the increase of the worm and dry weather soon destroys it. This observation has been made by many farmers long ago. A similar observation has long since been made in regard to the Cotton Louse. Early in the spring (when the cotton is in its first and second leaf), if the weather is rainy, the louse soon covers the tender cotton plant and threatens to destroy it. But when the dry season supervenes the little insect disappears, and the plant soon recovers from the mischief. To what shall we attribute the disappearance of the insect in both cases? It is evidently due to that little predatory and almost omnipotent ant which retreats to its hole and gathers in large bunches in dry places during the rainy seasons; but whenever the drought sets in, it climbs the stalk of every plant in search of prey. It is carnivorous and deals death and destruction among insects in the crawling stage of existence wherever it goes. When the Cotton Louse multiplies dangerously on the tender plant, favored by a rainy season, the farmer loses all hope of his crop unless the dry weather comes and the little ant begins to milk the cows (the lice are called "ant cows") by climbing up to them and striking them with their hands? and eating a fluid, which is made to exude from them, by the concussion. This process soon destroys them. Then, at a later season, especially if the ant is driven to its shelter by rains, the Cotton Worm, having increased to a dangerous extent, threatens the more mature plant. Again the same ant, when the sunshine permits, saves the cotton by climbing the stems and seizing the flouncing worm, cuts it into two on the ground, to which both have fallen in the struggle, and thus in a very short time it thinned out the worm, either destroying or holding it in abeyance.

"The history of these two enemies of cotton growers accords with the experience of observers. The dry weather, *per se*, does not save the cotton from louse or worm in the former or latter season only as it permits the predatory ants to destroy them; nor does the wet weather favor the production of the insect only as it drives the ants to their holes. Were it not for the ant the cotton plant would never make the first limb, or, escaping this, could not mature a single boll on account of its second enemy, the worms.

"Then let us curse the little biting ant no more when we happen to get a shoe full, but remember that we are indebted to this diminutive creature for every thread of cotton that has gone into the commerce of the world."

Thus you see that about ten years ago the Rev. N. A. Davis informs me of his discovery of the destruction of the Cotton Worm by the ant; to which I have added the additional fact of its destruction of the Cotton Louse earlier in the season by the same ant. The observation of each succeeding year since that time has confirmed me in the opinion, and our last summer, the driest I ever saw, yielded no specimens of the worm or louse within my observation. Please obtain the technical name of inclosed ant.

Yours, respectfully,

F. L. YOAKUM.

Prof. C. V. RILEY.

PERRY COUNTY, ALABAMA, *September* 17, 1879.

I beg leave to offer the following, in answer to your questions in regard to the habits of the Cotton Worm, and the best modes of destroying the same:

1. I can remember seeing cotton grown as far back as 1820 in Autauga County, Alabama. Since 1822 I have been cultivating the plant in Perry County on sandy land.

2. In 1837, about the middle of September, was the earliest I ever saw them. No damage of any consequence afterwards until 1866.

3. In my opinion, the worms are worse after a severe winter. I suppose it is because they come out oftener during mild winters and are consumed by the birds.

4. Hot, dry weather seems to be the life of them.

5. The 20th June is the earliest I have noticed them, but doing no serious damage until 20th July.

6. They invariably make their appearance first in the low, black lands of West Perry County.

7. They hide themselves in old barns and rotten trees during the winter, coming out in the afternoon of warm days.

8. The appearance of the worm does not seem to attract any kinds of birds to our fields but all domestic fowls devour them ravenously, as do also hogs and ants.

9. There has been no method adopted for destroying the moth successfully.

10. They are attracted in larger numbers by decayed fruit of almost any kind than by anything I know of (during night).

13. Paris green seems to be the most reliable mode of destroying them, though some of my neighbors have used London purple with good effect.

14. It is dangerous to men, animals, and cotton when used with indiscretion.

15. I have used kerosene oil, one part to thirty parts of water, effectually, and spirits of turpentine will do about as well. I believe pine sawdust sown *lightly* with the seed would be a preventive.

Yours, &c.,

O. H. PERRY.

Prof. C. V. RILEY.

WALTERBOROUGH, COLLETON COUNTY, SOUTH CAROLINA,
September 28, 1879.

I mail you this day my report, as requested by you in circular No. 7. This report is not as full as one I made last year to the department, but what I have said is founded on experience and close observation of the Cotton Worm for years.

Trusting that it may be of some use in your department,

I am, very respectfully, yours, &c.,

JAMES W. GRACE.

C. V. RILEY, *Chief U. S. E. C.*

1. Cannot state from any reliable authority, but cotton was grown soon after the settlement of the county for domestic purposes.

2. As early as 1793 the worm swept over the State, but it is first recorded in this district in 1800 as prevailing generally.

3. The worm is most to be dreaded after a mild, warm winter. He will make his appearance sooner in the following season.

4 Wet summers by all means favor its multiplication.

5. First of June.

6. In wet, low spots where the plant grows luxuriant, the plant being succulent, soft, and pulpy.

7. I believe that it is a peculiar parasite of the cotton-plant, and as such that the cryptic germ of the insect is to be found with the germ of the plant itself, and, like all parasites, only requires favorable circumstances to develop it; a soft, pulpy, and luxuriant state of the plant, with cool and cloudy weather at the time of its natural advent—that is to say, from early in June to middle of July—will cause it to develop vigorously and bud rapidly, so as to produce seasons; whereas dry June and hot weather, causing a hard, dry state of the leaves and mature condition of plants, furnishing but little and poor food, will result in a poor and a feeble brood, too inactive to do harm. This theory is borne out by the following facts: The Cotton Worm is found everywhere on the globe where cotton is planted, and only found on the cotton-plant. The worm will starve if the cotton-plant fails, though other vegetation abounds. When the plant is pushed on so as to grow and mature rapidly, the leaves being hard and dry in June, as was usual before the war, we hear nothing of the worm; but when cultivation is bad, the plant backward, and when June, the time of its natural development, comes, the worm finds the cotton (as since the war) green, sappy, soft, then does it rejoice in wholesome food, increase rapidly, multiply, and make itself a scourge.

I do not believe that the worm is migratory and returns to us from a warmer climate every year, for it can be found every year in small numbers if sought. I cannot admit this view, as I have seen it 300 miles from the coast at an elevation of 1,500 feet, in the northwestern corner of this State, in the month of June, and observed it there till the fields in August were totally destroyed. How could I believe that it got there by migration or was carried by currents of air? Nor can I believe that it hibernates around, as under old fences, on the south side of stumps, &c., as, first, our winters are too severe to render such a supposition plausible; and, again, since the late war, no fences exist to give such shelter on the islands of our coast, where the worm most prevails, and the universal fires that pass every fall over woodland and clearings would effectually destroy any moths or chrysolids.

Therefore it is clear to my mind that it is a peculiar parasite of the cotton-plant, and the cryptic germ of the insect is to be found with the germ of the plant itself.

Last year I made a very full report of this matter, and am sorry to learn that it was made no use of, and probably consigned to the paper-mill without being read.

8. Most all birds, such as the mockingbird and others, seem to be fond of the worm.

9. Paris green is the only thing that I have seen used, except fire-stands about the field. The latter is useless. Paris green is good, and the only thing I know of that will destroy them.

10. I should say near fire-stands.

11. I don't know of any.

12. Nothing.

13. There has nothing been found better than the Paris-green to destroy the worm.

14. I have not. With care there is no danger to man or beast.

15. Good cultivation. Push the plant early in the season.

16. The cost of keeping a good man and paying and feeding good hoe-hand, and this is the best means, and the cost is not very much.

JAMESTOWN, ALACHUA COUNTY, FLORIDA,
September 16, 1879.

In answer to your circular questions, the following is respectfully submitted:

3. The worm is most dreaded after mild winters.

4. Much rain in June and July seems to favor their development; but the character of the rains in those months in this section are short but frequent showers, with bright sunshine between showers. The writer has come to the conclusion from some observation that continued cloudy days are unfavorable to the development of the worm, and these reasons are given: Continued cloudy days are unfavorable to the hatching of the eggs; the sunshine seems to be needed with its greater heat. In cloudy weather the flies or moths will be on the wing throughout all hours of the day, thereby giving the birds and mosquito-hawks better opportunities to catch them. In such weather the worms stay on the top side of the leaves throughout the day, and consequently are more readily seen and caught by their enemies; while in hot, fair weather the moth is concealed during the day, and does its work in the twilight and at night, when the birds and other enemies are at rest. The worms, too, of the first crops seem to work or eat only in early and late parts of the day, and probably at night; generally from 8 or 9 o'clock a. m. till 4 or 5 o'clock p. m. they will be found quiet on the under side of the leaves. It is the belief of the writer that continued rains, with cloudy days, are unfavorable to the increase of the worm; cloudy days, even without rain, are unfavorable.

5. Have never seen the worm earlier than June.

6. Generally is seen first in moist, rich spots, where the cotton grows rapidly.

7. Have seen the moths at various times during the winter as "candle-flies." Suppose that those worms that come to maturity when winter is approaching, by instinct seek some place protected from cold, and, if not disturbed, might remain in chrysalis till the proper amount of heat would develop them into the moths. Those that are badly or slightly protected from cold may either be frozen by cold weather or warmed into life by a few warm days, while those that are properly protected, which probably are but few, will pass through the winter, and be revived only by the hot sun of May or June.

8. Almost all domestic fowls will eat the worm. Geese will eat them to some extent, while chickens, turkeys, guinea-fowls will grow fat on them. Almost all wild birds will eat them, and a large wasp, both black and red varieties, seem to be fond of the worm. In this section there are great numbers of a lace-winged fly, commonly called mosquito-hawks. These are of various sizes and colors, and are very expert in catching the moth on the wing. I believe this mosquito-hawk is very influential in preventing the progress of the worm.

While on this question I would like to state that it is my opinion that much good could be accomplished, and probably many fields might be saved, if birds that are insectivorous could be domiciled in the field. From what I have heard of the English sparrow it occurs to me that this would be the bird for the purpose. If bird-houses are located in various parts of the field, the birds would naturally hunt for insects near their homes, and the consequence, I think, would be that in all cotton-fields well supplied with these birds, the caterpillar would be kept down. If the English sparrow can be domiciled, that is, will stick to its house and feed around, it could be made of great benefit to the cotton region. The suggestion is offered for your consideration.

Very respectfully,

F. M. McMEEKIN.

C. V. RILEY, *Chief U. S. E. C.*

SAN ANTONIO, TEX., *September* 11, 1879.

I shall not answer your questions as I find them in the Herald of this city, for I presume there will be plenty of answers for you. My object is to state a fact bearing on the Cotton Worm. I planted cotton in the State of Nueva Leon, Mexico, five leagues below the city of Monterey, in 1857. Cotton had never been planted at the place, nor nearer than 200 miles to it in this world's history. I brought the seed from San Antonio, Tex., the ordinary Petit Gulf seed. The genuine Cotton Caterpillar appeared in the last days of May, and by the end of June ate up the crop. In the city of Monterey, at the same time, I planted in my garden (a large one) two patches of cotton—one the Texas seed, the other the black seed of the Sea Island genus, that is generally planted in Mexico. The distance between the two patches was, say, 200 yards. I received a note from my partner at the hacienda below Monterey, about ten o'clock in the morning, telling me that he had discovered the worm in the cotton field. I at the moment passed into my garden and *found the worm in both patches.*

Now, the question is, where did they came from? The egg or germ could not have been in the seed, as the butterfly cannot reach the seed to lay her eggs, and the gin would have destroyed them. I assert that they could not have been blown there, or have remained deposited in the earth from the creation thereof; yet they came. The weather was showery, hot, sultry, and between showers a hot sun. I have planted cotton all my life; have noticed the worm, and have always found them to come after such weather as I describe. When you walk between the rows after a shower, and a sort of hot steam vapor comes up, then look out for the butterfly. I also planted cotton in the Laguna, or Rio Nazas country, in the State of Durango, Mexico, in 1873-'74-75-'76, where we plant the black seed but once in five or seven years; as a general thing the same Cotton Worm to which I have been accustomed in Texas, came every year; but, as there is but little rain there, they seldom come before September, and too late to do much harm. Scientists say there is no original creation possible now; that all things of this world had their beginning when it was made; but I believe that the atmosphere created the germ right there. When I was a boy there were no cotton worms; now they never fail. These are points to which you are devoting your time, and so fraught are they with the interests of our people, that all will wish to aid you as they can; and I write this to state a fact, but which I know will add to your difficulty.

Respectfully,

H. P. BEE.

Prof. C. V. RILEY, *Chief U. S. E. C.*

SAN ANTONIO, TEX., *September* 29, 1879.

You do not agree with my theory, but it will bother you to find out where the Cotton Worm came from, under the circumstances, as stated in my previous letter.

There is no cotton growing *wild* in the part of Mexico where I resided, as there are heavy frosts there every winter; in the tropical region of the State of Vera Cruz, and to the south, large crops of cotton are raised, but I never saw a *wild* cotton plant.

The consul at Vera Cruz could, I have no doubt, give you an interesting account of the cotton plant in his section. I know that in the neighborhood of *Paso del Macho*, on the Vera Cruz Railroad, the cotton is bent down so as to stand the storms, and consequently the plant grows horizontally instead of perpendicular, and presents a curious appearance when ready to pick.

Some years ago there were large fields of cotton in the State of Coahuila, in the district of Monclova, but although admirably adapted to the production, the Cotton Worm from successive visitations entirely broke up the business, and now no cotton is planted in that State.

I planted cotton for four years on the Rio Nazas, or Laguna Country, in the State of

Durango. This is the *Nile* of America. The Nazas rises periodically (always once a year, sometimes oftener), and overflows a vast extent of country, a bold, clear, mountain stream, 200 miles long, finally emerges from the mountains into an immense plain. The banks become lower as the river descends, until by many months it winds its way into the lake or laguna, a body of water 90 miles long and 35 wide, with no outlet—a great body of fresh water on an elevation of, say, 3,000 feet, in the midst of a great dry desert. The water of the lake is not utilized, as the soil on its banks is poor, no alluvial deposit or growth denoting original formation, but rather that the lake had been produced there by some convulsion of nature, as, if it were the original deposit of the waters of this great river, there would be swamps and sluices and timber denoting that fact, as the mouths of the Red River and other streams in Texas and Louisiana. The haciendas of the laguna begin where the River Nazas emerges from the mountains, and is utilized by dams and canals and ditches, by which the overflow is restrained and the lands irrigated. This irrigation is seldom used more than once a year, as the extraordinary character of the alluvion deposit of centuries retains moisture sufficient to produce crops for two years if necessary. (It seldom rains, and rain is not depended on at all for crops.)

Cotton is planted once in seven years; is planted with a hoe. A hole is dug from 12 to 18 inches deep, to the moistnre, the seed deposited, and that is the start, which is expensive, but there is no other way, as the moisture is too low down to be reached by a plow. The cultivation is as with us: Frosts kill the plants, the stalks are cleared off and burned, and in the early spring with the budding of the peach tree the cotton sprouts, and gives you a start of three or four weeks over seed just planted. The "Planta" gives the best yield the third year; gives less, but a good crop, the fourth and fifth; and then produces as in the first and second years. The seed planted is the *black seed*, like the Sea Island and Egyptian; staple long and fine. The green seed, or American cotton seed, yields the first year better than the black seed will on the third year, but as that seed will not ratoon or grow again from the roots, and the expense of planting is so great, it is not generally used. Cotton produces a bale to the acre; corn and wheat, most extraordinary crops in these rich alluvials.

Cotton is planted at Santa Rosalie, in the State of Chihnahna, but not to a great extent; the climate is most too cold. This gives you all the information I have about the cotton region. With the exception of the Nazas and the Santa Rosalie, no cotton is grown in Mexico, except in the tropical regions of the Atlantic and Pacific coasts, as the rest of Mexico is generally table-land, with an altitude of from 3,000 to 7,000 feet, and a temperature too low for delicate vegetation

There is a mountain in the center of this vast alluvial plain of the Lagnna. In caves in this mountain are to-day the bodies of an extinct race of Indians, of whose existence in this plain there is no history extant. The bodies or mummies I have seen; they are wrapped in a species of cloth or matting made from the magnez, painted, and all in good preservation; the skin has dried, the hair is perfect; all in wonderful preservation. No iron, gold, silver, or other metal has been found in the cave. Pottery ware, of the same shape as the pictures we see of the old Egyptians, arrow-heads, and spear-heads of flint. It really is remarkable, and induces the belief that some sudden overflow of the river submerged the plain and drowned all the people; they were evidently used to high water, as they buried their dead in the caves of the high mountains. There are thousands of mummies in these caves. Excuse this long letter.

Yours, respectfully,

H. P. BEE.

Prof. C. V. RILEY, *Chief U. S. E. C.*

KIRKWOOD, MISS., *September* 5, 1879.

1. The cultivation of cotton, I am informed, was coeval with the settlement of the country. I settled here in 1845 and found cotton cultivated all over the county.

2. The boll worm has been an annual visitor since the first cotton was planted, destroying more or less, according to the character of the season. Though I had heard of the visitation of Aletia previously, I first observed it in 1858, though it did but little damage to crops that year.

3. It is more dreaded after a mild winter, but its visitations do not seem to be influenced more by one than the other; that is, they are as often seen after one as the other.

4. Cannot say that a wet season favors its multiplication. They are never developed during hard rains or continued wet spells. Their propagation seems to depend upon showery weather creating atmospheric dampness, and a high mean temperature. Dry weather is unfavorable to their production or increase.

5. The last week in July is the earliest period. Have often found, what is here called the grass worm, as early as May, eating both grass and cotton.

6. Its first appearance, in my observation, is along hillsides, where moisture is retained, and hollow spots on upland, just where in plowing after a season the plow encounters the wettest soil; such spots as generally produce the most luxuriant cotton.

7. About the middle of last November, and after several severe frosts, I found many chrysalides, of the last brood, on bare cotton stalks, living and lively. I placed these with others, previously brought in, in glass jars and boxes with earth and rubbish, exposed to outer air. Between the 15th and 20th of January, after a severe freeze of several days' continuance in December and January, a number of living moths came forth, in a warm spell then prevailing, but soon died. On the 6th of February the whole lot of chrysalids were then examined, when many were found to be dead and dried up, others again looking plump, which were inadvertently thrown away, and from the cases of others several varieties of living ichneumon flies were taken alive. One of them filling the case, and of normal size, was sent to Professor Riley and pronounced by him to be "*Pimpla conquisitor*," a parasite of *Aletia*. My impression now is that had they been left undisturbed the living moths would have issued forth this spring from a few.

I do not think the moth can survive the winter, as in its natural state and in confinement it is so short-lived in the summer, and my conclusion is that though it may be retarded in its transformations in our climate by cool weather, it was not designed by nature to hibernate in any of its phases, but is the creature of a semi-tropical climate, where it is perennial and completes the cycle of its existence uninterruptedly. It has followed cotton, its favorite food, into our temperate climate, has become indigenous, but has been subjected to abnormal changes, and only appears in large numbers during those periods when our climate assumes for a time a semi-tropical aspect.

Many of the moths leave their cases late in the fall, and many eggs as well as chrysalides are caught by the frost upon the cotton stalks and must necessarily fall to the ground with the detritus of the plant, and where there is much vegetable matter, as is the case in our fresh lands, and from the decomposition going on, would be well protected against frost. What goes with the moth, unless it dies, is a mystery, as I have rummaged everywhere without success, and in spite of rewards offered can hear of none from one season to the next. The general opinion is that they die out.

As the egg of the *Aphis*, a much more insignificant insect, but one greatly affecting cotton, is known to survive the winter, by analogy I do not see why the egg of *Aletia* may not likewise survive. The one, *Aphis*, is deposited on the stalk, and the other, *Aletia*, on the leaf; both go to the ground. *Aphis* appears almost coetaneously with cotton under its appropriate law, and why may not *Aletia* appear later from its ovum under its appropriate law?

8. Starling and a species of gregarious blackbird; ichneumon flies, and also a small, velvety-looking caterpillar, black, with two lateral yellow stripes.

9. Poisoned sweets near lights for the destruction of the moths were tried here many

years ago, and with some success. It was soon abandoned on account of the time and trouble, as well as expense, and has never been repeated. A moth-lamp attracted attention a few years since about Canton, but that, too, has flickered out.

10. Light would prove far more attractive than the sweet.

11. I know of no flower which attracts them.

12. Nothing.

15. As we usually, in fact invariably, see the worm before we see or hear of the moth, the aim would be to destroy the second brood, and this could be best done by putting out lights and sweetened poisons to attract the moths.

I will here reiterate what has been submitted in previous correspondence, that the propagation of the worms in destructive numbers is the result of imprudent tillage, and that by plowing wet land we hasten their production by an artificial process which good husbandry would teach us to avoid. He who will run his plows only when his lands are in good tilth, and the work will prove advantageous to the plant cultivated, will never have his cotton injured by the invasion of the Cotton Worm. I deem it unnecessary to go into detail, as my theory and plans have been elaborated in previous correspondence.

I have the honor to be, yours, respectfully,

E. H. ANDERSON.

Prof. C. V. RILEY, *Chief U. S. E. C.*

[Dr. Anderson's theory, referred to in the above report, and as set forth in an extensive correspondence, may be thus stated: In 1858, in the month of July, on visiting his cotton field early in the morning, he found his overseer running a number of plows on a hill side adjoining bottom land, where the soil was wet. He ordered the plows to be stopped, believing that the work would fire the cotton and cause it to shed, and perhaps injure the land by baking the wet sod in the hot sun. In ten days the worm was discovered in the cotton, and in twenty days there was not a leaf or young boll to be found upon it, and what especially surprised him was that the worms did not touch adjoining cotton or cross the plowed furrows. Since that time he has often witnessed a similar occurrence, and others have had a like experience, so that he gradually came to consider that there was cause and effect. He made experiments which seemed to confirm that belief, and finally reached the conclusion that, either the moth, unobserved, had deposited her eggs upon the stocks, or the eggs of the previous season had fallen to the ground with the leaf of the plant and, being protected by the detritus, had survived the winter. To use his own language:

"Under ordinary circumstances, from the albuminous nature of the egg, it would be affected by heat and moisture naturally; that is, by solar action on rain and dew, creating vapor, which quickens it into life, by inducing fermentation and putrefaction, without which no egg could be hatched and no germ vivified. Under the influence of cold these chemical forces would be dormant, and the embryo or germ would remain quiescent. The necessary atmospheric conditions do not recur annually for the speedy propagation of the *Anomis*, and hence we do not have them in destructive numbers except in propitious seasons. * * * It is a fact, patent to all practical farmers, that, if their land is plowed while wet or too wet for good tilth, the corn or the cotton, as the case may be, is injured thereby—fired, as it is termed; the corn turning yellow and being arrested in its growth, while the cotton sheds its leaves and droops. Why is this? I should say because the clod is exposed to rapid solar evaporation, and the hot steam damages the plants, through its respiratory, and impedes the normal functions of all of its organs by disturbing the healthy equilibrium of the air. That an abnormal degree of heat is produced by this process is proved by the application of the thermometer, as I know by experiment; and every farmer knows that the hottest and most oppressive work is plowing wet land under a hot sun." It cannot need proof to show that when by plowing you disturb the capillarity of the earth while damp, abnormal heat is produced by the more rapid evaporation of the upheaved soil. This is as certainly true as that a shower, by restoring or re-establishing capillarity, will cool down the earth.

"Now, my theory is that the damp artificial heat produced by the process of plowing wet land is the most favorable of all conditions for hatching speedily the eggs of the insects, and especially when you add to this the extrication of ammoniacal gases, which under such circumstances must be more abundantly evolved. This I hold to be the solution of the mystery of speedy generation in the wetter portion of cotton fields."

The plan of prevention Dr. Anderson proposes on this theory is, never run the plow in May and June south of his latitude, or in July and August farther north, when the land is wet and not in good condition for plowing. If there are frequent rains, he believes it matters little when or how the plowing is done; "for so long as the rain continues, the necessary physical conditions cannot be produced—shower succeeding shower in rapid succession keeps the temperature of both air and earth cooled down and is inimical to the worm. When, however, showers at longer intervals occur, and the temperature is high, and the plowing produces rapid evaporation, and the plowman, reeking with sweat, pants for a breath of pure, dry, fresh air, then the *Anomis*, nurtured into life by its genial surroundings, commences its revels, and in a short while the luxuriant cotton is converted into bare and blackened stocks."

"You must make cotton as you make hay; that is, while the sun shines. The diligent farmer who keeps even with his work can always afford, without detriment to his crop, to let his plows rest until he can do good work; but if plow you must, to kill grass and the rain wont stop, throw your furrows into the middle of your rows and not to your cotton, as by this process the danger of developing the worm is less, and no injury is done to your plant."

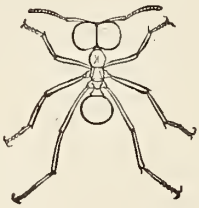
Dr. Anderson, nevertheless, admits that "a few of the insects are annually hatched by a natural process; enough to perpetuate the species." A similar theory to this one of Dr. Anderson's is held by a number of planters, founded, of course, on the observed influence of soil and weather on the development of the worm; but in so far as any such theory implies the hibernation of the egg, or the spontaneous generation of the insect, or in so far as it departs from the reasoning on pages 18–19 of this Bulletin, I believe it to be fallacious.]

[The following condensed summary of the habits of the worm is from that excellent observer Dr. D. L. Phares, of Woodville, Miss.:]

"The caterpillar generally makes its first appearance at or about the same spot in a field year after year, partially or wholly denuding a few square rods or an acre or two. That is the first appearance *generally* noticed by planters. Close observers find a few earlier, and only a few leaves nibbled on only a stalk or two of cotton. In due time the moths from this first, or rather second, brood deposit their eggs in all parts of the field when the foliage is in right condition for feeding the young. In a few days more all parts of the field are stripped simultaneously, that is, so far as eaten at all. This when the destruction is early. When broods are smaller, the successive generations appear for three, five, and even seven months.

"They are not Army Worms. They usually hatch and pass through all transformations on the same plant on which the egg is deposited. If accidentally thrown off, they return to the plant when practicable. Sometimes violent storms of wind and rain sweep nearly all off and wash them up in vast heaps against fences, &c., where they putrefy. Dry, hot sunshine seems to destroy them in all stages; and sometimes, under such conditions, they abandon the partially denuded plants and move in immense masses from the field; not so often, it seems to me, for other food, as to escape the intense heat. Under such conditions one rarely ever ascends another cotton plant. Their march is to death. If a road be in the way and dusty, and still worse sandy or gravelly, few succeed in passing the barrier. The exposed hot ground kills them, and sometimes we have seen them in the road-side ditches several inches deep, infecting the air with putrefactive stench.

"Another point: If the moth deposits no eggs in any part of a field, no caterpillars will attack that part. She knows evidently where the young can subsist and where not, and she deposits her eggs accordingly. If the plant is in condition to feed the moth, I suppose it is in condition to hatch and feed the young. Little or no difference is perceptible by the common planter in the condition of the plant on two sides of a line that may divide an injured and uninjured field. A little distance from the line the difference is not perceptible. The plant is not so tender. Its chemical and mechanical condition both unfit it for the food of the caterpillar; therefore the moth deposits no eggs on it, nor will the caterpillars if placed on it eat it. This is specially and annually noticed on rolling or undulating lands, and sometimes on lands to the eye apparently level. This is my fortieth crop on the lands where I reside, and in no year has my whole crop been eaten off. The crops are often destroyed in Madison County and other points north as well as south of me before any damage is done here by the caterpillar. This depends on condition of plant."



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Z.

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EXPLANATION OF PLATE 1.

A healthy stalk of wheat on the left, the one on the right dwarfed and the lower leaves beginning to wither and turn yellow; the stem swollen at three places, near the ground where the flaxseed (*h*) are situated, between the stem and sheathing base of the leaf.

a, egg of the Hessian Fly (greatly enlarged, as are all the figures except *e* and *h*).

b, the larva, enlarged, the line by the side, in this and other figures, showing the natural length.

c, the flaxseed, puparium or pupa case.

d, the pupa or chrysalis.

e, the Hessian Fly, natural size, laying its eggs in the creases of the leaf.

f, female Hessian Fly, much enlarged.

g, male Hessian Fly, much enlarged.

h, flaxseed between the leaves and stalk.

i, Chaleid or ichneumon parasite of the Hessian Fly, male, enlarged.

Figs. *b*, drawn by Mr. Riley; *d* and *f*, by Mr. Burgess; *a*, *g*, and *c*, *i*, by the author; drawn on wood by L. Trouvelot.

THE HESSIAN FLY AND ITS TRANSFORMATIONS.

EXPLANATION OF PLATE II.

Fig. A. Side view of the female Hessian Fly, greatly enlarged.

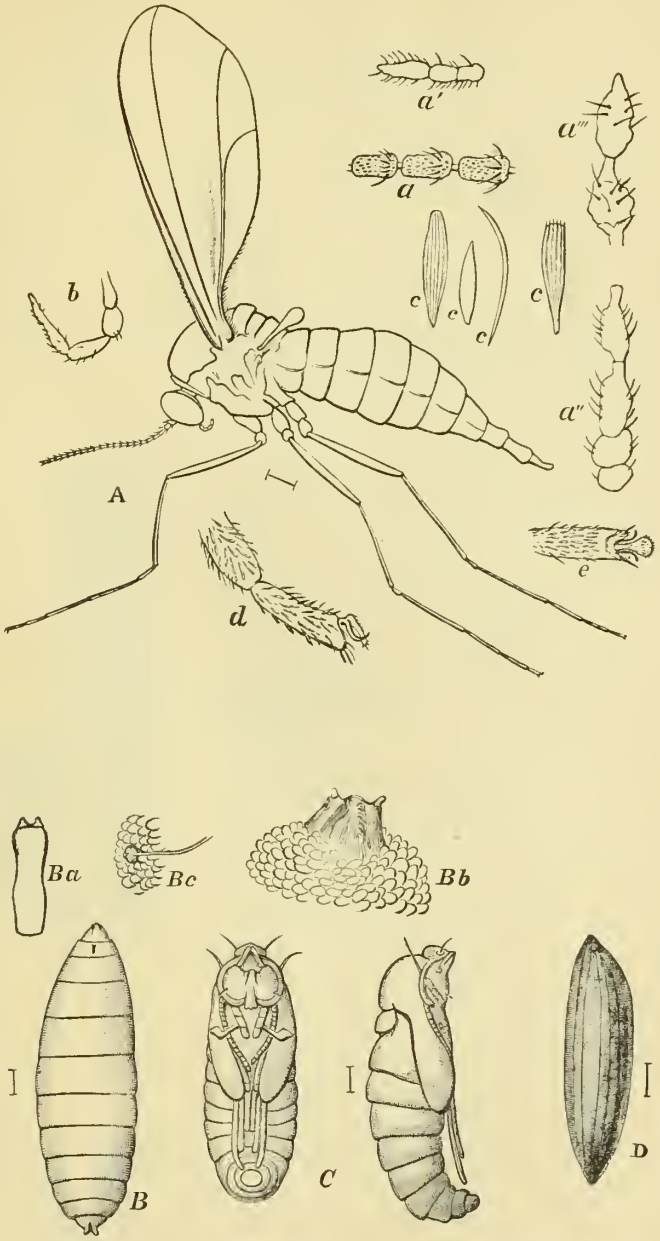
a, three joints taken from the middle of the antennæ of the female; *a'*, the three terminal female antennal joints; *a''*, the four basal, and *a'''*, the two terminal male antennal joints; *b*, a maxillary palpus; *c*, scales from the body and wings; *d*, *e*, side and vertical view of the last joint of the foot, showing the claws and foot-pad or pulvillus between them, and the scales on the joint. Drawn by Mr. E. Burgess.

Fig. B. Larva magnified, with the breast-bone in the 2d ring next to the head.

B*a*, the breast-bone highly magnified; B*b*, head from beneath, enlarged; B*c*, larval spiracle and its tubercle and trachea leading from the spiracle. B, drawn by Mr. Riley; B*a*, *b*, *c*, by Mr. Burgess.

Fig. C. Side and front view of the pupa or chrysalis. Drawn by Mr. Burgess. The abdomen of the side view of pupa is rather long, as the insect, when drawn, was just emerging from the semi-pupa stage, which it assumed December 1st.

Fig. D. The flaxseed, puparium, or pupa case. The line by the side of the complete figures denotes the natural length of the insect.



TRANSFORMATIONS OF THE HESSIAN FLY.